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Abbreviations and Acronyms

ADB — Asian Development Bank
a.i. — active ingredient
ARC — Agricultural Research Corporation (Sudan)
ARTT — advanced rust tolerance trial
ASPEC — Asian and Pacific Council
ASET — AVRDC soybean evaluation trial
AVRDC — Asian Vegetable Research and Development Center (IARC)
AYT — advanced yield trial
AzMV — adzukibean mosaic virus
BCMV — bean common mosaic virus
BlCMV — blackeye cowpea mosaic virus
BLS — bacterial leafspot
BST — botanical seed trial
BW — bacterial wilt
CARDI — Caribbean Agricultural Research and Development Institute
cc — cubic centimeter
CCC — Chloroephyltrimethyl-ammonia acid
CGIAR — Consultative Group on International Agricultural Research
CIP — International Potato Center (CGIAR)
CIPA II — Centro de Investigacion y Promocion Agropecuaria (Peru)
CIRAD — International Cooperation Center of Agricultural Research for Development (France)
CLS — Cercospora leafspot
cm — centimeter
CMS — Cytoplasmic male sterile
CPA — chlorophenoxyacetic acid
CTA — Technical Centre for Agricultural and Rural Cooperation (EEC)
CV — coefficient of variance
CMS — cytoplasmic male sterility
DAE — days after emergence
DAG — days after germination
DAIS — District Agricultural Improvement Station (Taiwan)
DAP — days after planting
DBM — diamondback moth
DMRT — Duncan's multiple range test
DNA — deoxyribonucleic acid
EC — electroconductivity
EEC — European Economic Community
ELISA — enzyme-linked immuno-sorbent assay
EVA — ethylene vinyl acetate
FFTC — Food & Fertilizer Technology Center (IARC)
g — gram
GA — gibberellic acid
GERDAT — Groupement d'etudes et de recherches pour le developpement (France)
GR — germination rate
GTZ — German Agency for Technical Cooperation
GYT — general yield trial
ha — hectare
HES — Horticultural Experiment Station (Korea)
IAAS — Institute of Agriculture and Animal Science
IAEA — International Atomic Energy Agency (UN)
IARC — International agricultural research center
IBPGR — International Board for Plant Genetic Resources (CGIAR)
IDRC — International Development Research Centre (Canada)
IITA — International Institute of Tropical Agriculture
IMN — International Mungbean Nursery (AVRDC)
INIA — Instituto Nacional de Investigaciones Agricolas (Mexico)
INIPA — Instituto Nacional de Investigacion y Promocion Agropecuaria (Peru)
INRA — Institute national de la recherche agronomique
INTSOY — International Soybean Program

IRAT — Institut de recherches agronomiques tropicales et des cultures vivrieres(France)
IRRI — International Rice Research Institute (CGIAR)
IRTT — intermediate rust tolerance trial
IYT — intermediate yield trial
JICA — Japan International Cooperation Agency
kg — kilogram
KPS — Kamphaeng Saen (Thailand)
m — meter
MARDI — Malaysian Agricultural Research and Development Institute
ml — milliliter
mm — millimeter
NIAR — National Institute of Agrobiological Resources (Japan)
NIAS — National Institute of Agricultural Sciences (Japan)
NSC — National Science Council (Taiwan)
NAFFIC — Netherlands Universities Foundation for International Cooperation
NVRS — National Vegetable Research Station (UK)
OYT — observational yield trial
OP — open-pollinated
PCARRD — Philippine Council for Agriculture & Resources Research and Development
PIP — Postharvest Institute of Perishables
PM — powdery mildew
POP — Philippine Outreach Program (AVRDC)
ppm — parts per million
PRTT — preliminary rust tolerance trial
PSU — Pangasinan State University (Philippines)
PVY — potato virus Y
PYT — preliminary yield trial
RH — relative humidity
RNA — ribonucleic acid
RYT — regional yield trial
SMV — soybean mosaic virus
t — metric ton
TARI — Taiwan Agricultural Research Institute
TLCV — tomato leafcurl virus
ToMV — tomato mosaic virus
TOP — Thailand Outreach Program
TuMV — turnip mosaic virus
TYLCV — tomato yellow leafcurl virus
UPLB — University of the Philippines at Los Baños
USAID — United States Agency for International Development
USDA — United States Department of Agriculture
ViSCA — Visayas State College of Agriculture (Philippines)
WAG — weeks after germination

Horticultural Crops Program

Chinese Cabbage Breeding

Evaluation of New Germplasm

Introduction

In search of genetic resources to be utilized in breeding programs, AVRDC subjects newly collected germplasms to routine evaluation trials. This year one trial was done for heat- tolerance and yield-related characters in summer cultivation. Another evaluation trial was for resistance to bacterial soft rot. In both tests some old accessions which looked promising in the spring evaluation of the Genetic Resources and Seed Unit (GRSU), were also included for confirmation.

Materials and Methods

Twenty-four entries with two check cultivars, ASVEG 1 and SL 4, were included in a trial to assess heat tolerance and yield-related characters. Fifteen from them were used in another planting with a susceptible check, B 141, and a resistant check, B 639, to test their reaction to soft rot. Both trials were sown on June 4 and transplanted on June 24 to 4-m-long, double-row beds, 150 cm apart, with a spacing of 50 cm between rows in beds and 40 cm between plants.

The randomized complete block design was employed for both experiments with two replications. Heat tolerance was judged by the ability to form compact heads under the hot weather conditions of the trial. In the soft rot screening artificial inoculation was done twice by our pathologists at an interval of two weeks during the heading stage. Readings of infection rate were done just prior to the second inoculation and two weeks later.

Results and Discussion

Six entries, in addition to two checks, were heat-tolerant. Four of them were newly collected materials, all F1 hybrids from Taiwan. Table 1 shows the yield and other horticultural characters of those accessions and a check, ASVEG 1. Statistical analyses were not done because it was not possible to collect data from many entries which are heat-sensitive. Three heat- tolerant entries were comparable to ASVEG 1 in yield and harvest rate, and NL 28 had much higher soft rot infection than the check and other heat-tolerant entries.

Table 1. Yield and other horticultural characters of newly collected heat-tolerant germplasm.

Acc.No./ Cultivar	Marketable Yield (t/ha)	Maturity (DAT)[z]	Head Wt. (g)	Heading Rate (%)	Harvest Rate (%)	Soft Rot (%)
NL 25[y]	24.4	35	731	100	100	0
NL 26[y]	26.4	35	793	100	100	0
NL 27[y]	28.0	38	838	100	100	0
NL 28[y]	7.0	50	1.093	100	19	85
ASVEG 1 (check)	29.7	35	951	100	97	3

[z]DAT = days after transplanting. [y]Numbers given for temporary identification to unaccessioned germplasms.

Soft-rot-infection rates of some entries are presented in Table 2. Two newly collected accessions showed similar or lower rates than the resistant check. However, both are heat sensitive. On the other hand, all heat-tolerant materials showed much higher infection rates. Considering such obviously contrary trend between heat tolerance and soft-rot resistance and the nature of the disease which usually becomes serious starting at heading stage, low infection rate in nonheading or heat sensitive materials may not really mean a high degree of resistance. In this regard, the development of a screening methodology which can solve such associated problems efficiently is crucial in the identification of resistant materials and their further utilization in breeding programs.

Table 2. Soft-rot infection rate (%) and heat reaction of selected germplasms compared to susceptible and resistant checks.

Entry	Infection Rate[z] in		Heat Reaction
	1st eval.	2nd eval.	
NL 25	21 cde	70 b-d	HT
NL 27	32 b-e	64 b-e	HT
NL 28	15 de	63 b-e	HT
NL 22	7 e	19 f	HS
NL 23	7 e	40 def	HS
B 141 (Sus. check)	97 a	100 a	MT
B 639 (Res. check)	19 cde	40 def	HS

[z]Evaluated twice with two weeks interval. Mean separation within columns by Duncan's multiple range test, at the .05 probability level.

Conclusion

Four entries, NL 25, NL 26, NL 27, and NL 28, proved to be heat tolerant and the former three were comparable to the check, ASVEG 1, in yield and harvest rate. Though soft-rot infection rate of two entries were as low as the resistant check, this rate seemed to be associated with the inability of both entries to form heads.

Combining Ability Trials

Introduction

In combining ability trials, new heat-tolerant combinations with a better performance than ASVEG 1 were sought for. Special attention was paid to some important preference traits in target areas, such as head shape, color, and leaf pubescence. A group of lines in the relatively earlier generation of inbreeding were also tested for their general combining ability (GCA).

Materials and Methods

Twenty lines derived from various AVRDC open pollinated (OP) cultivars were crossed with a heterozygous topcross tester, B 129, in the 1984-85 cool season. The resulting combinations were sown on July 1 and transplanted on July 18 together with the pollen parent and the check, ASVEG 1. Eighty-one crosses were made between newly developed inbreds and previously bred tropical lines or among the newly developed ones. They were divided into three different batches.

The first batch, 29 combinations between OP derived lines and tropical inbred lines, were also sown on July 1 and transplanted on July 18. The second batch included 24 combinations between the new OP derived lines. This set was sown and transplanted on the same dates as the first batch. The last batch with 27 combinations between the lines derived from the TuMV backcross program and the tropical inbred lines were sown on July 4 and transplanted on July 23.

The randomized complete block design was employed in each of the four trials with two replications. Each plot consisted of a 4-m-long, double-row, raised bed. Spacing was 50 cm between rows on

a bed, 150 cm between adjacent beds, and 40 cm between plants within rows. ASVEG 1 was included in each trial as the check.

Yield and other horticultural characters were compared with those of the checks, for all entries in the GCA test. In the specific combining ability tests, these data were taken only from the remaining combinations after discarding the entries judged as undesirable from field observations throughout the growing period.

Results and Discussion

From twenty entries in the GCA trial, it was possible to select seven lines with performances comparable to ASVEG 1 (Table 3). The crosses were generally poorer in uniformity than ASVEG 1. Considering the heterozygosity of the topcross tester, however, the parental inbred lines could be regarded as uniform enough. Their higher head shape index (length/width of the head) implies that these lines may enable us to develop combinations with longer head shape which is preferred in many of our target areas.

No entries outperformed ASVEG 1 in yield from any of the three batches with specific combinations (Tables 4 to 6). However, we have selected five and three entries from Batch I and Batch II, respectively, for their overall appearance and/or uniformity. These selections are generally higher in head shape index than ASVEG 1, and showed a similar or longer period of maturity by one week.

Table 3. Yields and other horticultural characters of selected heat-tolerant OP-derived inbreds when crossed with B 129 as topcross tester.[z]

Entry	Yield (t/ha)	Days to Maturity	Harvest Rate (%)	Head Wt (g)	Solidity	Soft Rot (%)	HSI[y]	Uniformity[x]
85GC03	29.5 ab	35 bc	99	912 a	.62	3 bcd	1.60 ab	Fair-Good
85GC05	29.2 ab	33 c	100	877 a	.55	0 d	1.65 a	Fair
85GC06	28.2 ab	33 c	94	903 a	.60	12 abc	1.55 abc	Good
85GC09	27.8 ab	36 b	97	892 a	.63	7 bcd	1.45 a-d	Fair
85BC11	26.1 b	33 c	95	894 a	.64	21 ab	1.40 a-d	Good
85GC12	28.3 ab	33 c	99	874 a	.65	18 abc	1.35 bcd	Good
85GC15	31.6 a	33 c	99	977 a	.69	10 a-d	1.45 a-d	Good
ASVEG 1 (check)	28.2 ab	33 c	100	846 a	.72	15 abc	1.25 d	Good-Excellent
LSD .05	4.0	2	NS	133	10	-	.23	

[z]Mean separation within columns by Duncan's multiple range test at the .05 probability level. [y]Head shape index head length/head width. [x]Overall observation on morphology and color of head and leaves at maturity.

Table 4. Yields and other horticultural characters of the best combinations in the combining ability trial (Batch I) of crosses between OP-derived lines and tropical inbreds.[z]

Entry	Yield (t/ha)	Harvest Rate (%)	Heading Rate (%)	Head Wt (g)	Days to Maturity	Soft Rot (%)	HSI[y]	Uniformity[x]
85101	31 a	99 a	100 a	966 a	39 bc	1	1.55 bcd	Good
85107	30 ab	94 a	99 a	972 ab	39 bc	1	1.70 a	Good
85118	30 ab	97 a	99 a	981 a	36 d	7	1.65 ab	Good
84120	28 a-d	100 a	100 a	833 a-d	33 e	1	1.40 efg	Good
84125	26 b-d	95 a	100 a	852 a-d	38 cd	5	1.50 cde	Good
ASVEG 1 (check)	27 a-d	99 a	100 a	829 a-d	33 e	10	1.35 g	Good-Excellent
LSD .05	4.6			137	2	NS	0.13	

For footnotes, please refer to Table 3.

Two combinations were selected from Batch III for their smooth-textured and dark-colored leaves which are characteristics preferred in some countries. All the selected combinations were comparable to ASVEG 1 in yield. Their heading and harvest rates were 100%. Soft rot infection was also minimal (0-7%) in the selected combinations.

Conclusion

Ten promising combinations whose appearance and performance were comparable, if not superior, to ASVEG 1, were selected for inclusion in next year's advanced yield trials. Seven inbred lines derived from OP selections showed better general combining ability than others evaluated together.

Table 5. Yields and other horticultural characters of the best combinations in the combining ability trial (Batch II) of crosses between inbreds derived from tropical OPs.[z]

Entry	Yield (t/ha)	Harvest Rate (%)	Heading Rate (%)	Head Wt (g)	Days to Maturity	Soft Rot (%)	HSI[y]	Uniformity[x]
85202	31 a	97 a	100 a	1,004 a	37 c	3	1.85 ab	Good
85216	31 a	100 a	100 a	937 a	32 d	5	1.70 bcd	Good
85220	29 ab	99 a	100 a	912 a-d	35 cd	1	1.70 bcd	Good
ASVEG 1 (check)	28 abc	100 a	100 a	833 cde	32 d	1	1.30 g	Good-Excellent
LSD .05	6			105	3	NS	0.14	

For footnotes, please refer to Table 3

Table 6. Yields and other horticultural characters of the best combinations in the combining ability trial (Batch III) with crosses between lines from TuMV-resistance backcross program and tropical inbreds.[z]

Entry	Yield (t/ha)	Harvest Rate (%)	Heading Rate (%)	Head Wt (g)	Days to Maturity	Soft Rot (%)	HSI[y]	Uniformity[x]
85310	25	99 ab	100 a	772 a	31 c	1	1.50 ab	Good
85327	19	100 a	100 a	569 c	28 d	0	1.50 ab	Good
ASVEG 1 (check)	20	99 abc	100 a	607 c	28 d	1	1.50 ab	Good
LSD .05	NS	–	–	88	2	NS	0.13	

For footnotes, please refer to Table 3

Advanced Yield Trials

Introduction

The same set of F1 hybrids which were previously selected from the 1984 combining ability trials was included in four consecutive advanced yield trials throughout the summer season this year. These trials were conducted to confirm the performance of the combinations and to generate information on their stability over different growing environments before including them in the regional and international yield trials.

Materials and Methods

The ten best combinations were selected from the combining ability trials in 1984 and included in the advanced yield trials scheduled as below:

	Sowing date	Transplanting date
AYT I	May 10	May 31
AYT II	June 11	July 5
AYT III	July 10	July 30
AYT IV	July 25	August 14

Three cultivars, including ASVEG 1, were used as checks in each of these trials. Field layout followed the randomized complete block design with four replicates. Two raised double-row beds with a length of 4 m consisted a plot. Bed width was 1.5 m from one center to the next. Spacing was 50 cm between two rows within beds and 40 cm between hills. Field management followed AVRDC's standard cultural practices. Data were collected on yield and other horticultural traits, and preferred characters were recorded at proper stages of growing.

Results and Discussion

Table 7 shows yield, harvest rate, head weight, and days to maturity of three best-performing entries along with two checks, ASVEG 1 and SL 4. Data are presented from only three trials, for the first trial was destroyed by heavy rain and flooding. Combined analyses were not done because of the low degree of freedom which would result in poor confidence in estimation. The combination 83-21 significantly outyielded ASVEG 1, depending upon the trials, and was longer in head size and later in maturity than ASVEG 1. Other two combinations were not significantly different in maturity and yield from ASVEG 1.

All three entries showed almost perfect heading rates (= 100 %). Combinations 83-2 and 83-21 have smooth leaf texture which, in Taiwan, is more preferred than the puckered, hairy texture of ASVEG 1 (Table 8). Two combinations, 83-2 and 83-20 will be included in regional and international

Table 7. Yield, head weight, harvest rate, and days to maturity of the selected combinations in three advanced yield trials.

Entry	Yield (t/ha)			Head Wt. (g)			Harvest Rate (%)			Days to Matu.		
	II	III	IV	II	III	IV	II	III	IV	II	III	IV
83-2	24	19	15	705	573	444	100	99	100	33	31	30
83-20	28	18	19	838	554	571	100	98	100	34	31	32
83-21	33	20	22	1,043	619	668	98	100	100	39	33	35
ASVEG 1(Ck 1)	26	18	17	783	563	505	100	96	100	33	31	31
SL 4 (Ck 2)	22	16	14	648	478	435	100	100	100	31	31	30
LSD .05	4	3	2	88	78	57	–	–	–	3	1	2

Table 8. Preferred characters of the combinations selected from advanced yield trials.

Entry	HSI[z] in AYT			Puckering[y]	Hair	Leaf Color[x]	Uniformity[w]
	II	III	IV				
80-2	1.28	1.43	1.25	ML	No	G	Good
80-20	1.48	1.63	1.43	MH	Yes	LG	Good
80-21	1.28	1.50	1.45	M	No	G	Fair
ASVEG 1	1.28	1.60	1.40	H	Yes	G	Good
SL 4	1.30	1.40	1.33	L	No	DG	Good
LSD.05	0.10	0.13	0.12				

[z]Head shape index: length of head/width of head [y]H = high, MH = moderately high, ML = moderately low, and L = low degree of puckering. [x]G = green, LG = light green DG = dark green. [w]Overall rating for morphological characters.

trials in 1986. However, 83-21 has yet to be further improved for its uniformity since its sibbing rate was unacceptably high. In this regard, the female parent of this combination needs more intensive studies on the self-incompatibility reaction.

Conclusion

To select better performing and stable combinations, the ten best combinations from the 1984 combining ability trials were tested in four advanced yield trials. Three combinations were similar or superior to ASVEG 1 in yield. These combinations also seemed to have more desirable characteristics relative to preference, than the check, ASVEG 1.

Hakuran Backcross Program

Introduction

Hakuran, a synthetic *Brassica napus*, resistant to both soft rot and downy mildew had been utilized as donor parent in a backcross program to transfer the resistant gene(s) to tropical Chinese cabbage. The 1984 observations on backcross families showed, however, that more advanced generations tended to have lower levels of resistance to downy mildew. Backcross families, advanced once more during the 1984-1985 cool season, were planted to see whether such trend is true in the fall season and to test their heat reaction in the summer season. Summer planting was also assessed for soft-rot reaction.

Materials and Methods

For the heat-tolerance test, 14 backcross families of BC5 F1 BC2 F4 were sown with recurrent parent B 129, and heat- tolerant check ASVEG 1 on July 4 and transplanted on July 24. The randomized complete block design was employed with two replications in 4-m-long double-row beds. Distance between beds was 150 cm from center to center. Spacing was 50 cm between rows within beds and 40 cm between hills within rows. Immediately after observation on heat tolerance (heading ability under hot weather) at heading stage, the plants were inoculated with soft rot; and the infection rate was investigated two weeks later.

Twenty-seven families, including 14 in the previous test, were sown on September 27 and transplanted to a downy mildew nursery on October 16. Population size was around 120 plants/family. Bed formation and spacing was the same as in the heat tolerance test. A highly susceptible cultivar, Ping-Luh, was planted after every two plants of backcross families.

The whole experiment was surrounded by two rows of the susceptible cultivar. Donor parent B 639 and recurrent parent B 129 were also included for comparison. Disease severity was scored on December 5, and selection for the most resistant segregants was made on December 10. To induce severe downy mildew, the field was kept humid by frequent furrow and/or sprinkler irrigations.

Results and Discussion

All plants in the 11 out of 14 families included in the heat tolerance screening successfully formed tight heads under hot temperature conditions of the summer season. The remaining three families showed poor heading ability, depending upon the individual plants. Thus, in most families, the backcross program could be regarded to have already attained the recovery of the heat-tolerance level of the recurrent parent.

However, soft rot infection-rate after artificial inoculation was not lower than that of ASVEG 1; and furthermore, only two families showed significantly lower scores in downy mildew severity; all others were statistically not different from the susceptible check (Table 9). The loss of resistance might be attributed to the deletion of the resistant genes in the course of backcrossing either by preferential paring within chromosomes originating from the recurrent parent, excluding those from Hakuran, or by the association of the resistance with undesirable morphology which was culled out in selection.

The screening method for soft rot, hardly good enough to create uniform disease pressure and remove secondary and tertiary infections, probably jeopardized the selection practices from one to the next generation in the course of backcrossing and segregation.

Table 9. Reaction to heat, soft rot, and downy mildew of selected Hakuran backcross families.

Family/Pedigree	Generation	Reaction[z] to heat	s-r(%)	dm	No.Plants Selected[y]
(B 639)/B 129// 1/-6/ 1/RP	BC5 F1	HT	38	NS	8
(B 639)/B 129//-1/ 6/ 4/RP	BC5 F1	HT	35	NS	13
(B 639)/B 129//-1/ 3/-1/RP	BC4 F1	HT	32	NS	17
(B 639)/B 129// 10-1-3/RP	BC3 F1	HT/HS	33	**	9
(B 639)/B 129// 10-1-3 x	BC2 F4		--	--	8
(B 639)/B 129// 10-3-1 x	BC2 F4	HT	28	*	8
B 639[x]	Donor	-	-	**	-
Check[w]			34		
LSD			NS		

[z]s-r = soft rot, dm = downy mildew. The asterisks indicate that the disease score is lower than that of the susceptible check, B 14, at the 0.05 (*) and 0.01 (**) probability levels. [y]Selections were made from the downy mildew screening nursery. [x]B 639 was not included in the planting for heat and soft rot resistance screenings. [w]ASVEG-1

Despite the disappointing general loss of disease resistance, selections were made for healthy, early-maturing, and well shaped plants from several families including the two with less downy mildew infection. These selections, whose leaf tissue generally looks tougher than that of the ordinary Chinese cabbages, will be used to develop tropical hybrid and OP cultivars.

Conclusion

Heat tolerance was satisfactory in the majority of the families, but disease resistance was disappointingly lower than that of the donor parent in all families, except for the downy mildew reaction in two families which were still significantly more resistant than the check. Selections, however, were made for families and plants with good general morphology and low downy mildew infection to be utilized as parental source in developing tropical varieties.

Breeding for TuMV Resistance

Introduction

The AVRDC Chinese cabbage improvement program considers resistance to turnip mosaic virus (TuMV) one of its major objectives. Recent identification of different strains has made it possible to work on this disease more systematically. In 1985, in cooperation with our virologists, progenies of B 730, an obsolete F1 hybrid previously found to possess resistance to all five known strains of TuMV, were tested for genetic purity with respect to resistance to these strains. Important breeding materials were screened to assess their reaction to each strain.

Materials and Methods

Progenies of 15 B 730 plants produced either by self-pollination or by mixed pollens collected from all entry plants were initially screened for resistance to the strain TuMV-C5 by artificial inoculation. Families selected therefrom were later screened for resistance to each of the five strains. Twenty to twenty-five plants per strain per entry were used in each screening. Plants were inoculated at the three-to-five true-leaf stage, and symptoms were recorded two to three weeks after inoculation. A confirmatory ELISA test was done whenever needed.

Two different sets of inbred lines (consisting of 15 and 19 breeding lines, respectively) were screened with each of the five strains. A susceptible check, B 40, and a resistant check, B 730 were included in the screenings. Inoculation and symptom reading procedures were the same as in the preceding paragraph. Five lines showing resistant reactions were sown again for two additional screenings for confirmation. In one screening, half of the entries were inoculated with the inoculum mixture of all five strains, while in the other half, with each strain separately.

Results and Discussion

F2 families of B 730 showed various rates of infection with TuMV C5, ranging from 1.9% to 25%. Four families with the lowest infection rates were rescreened with each of the five strains. The results are presented in Table 10. No single plant was infected in all the four families when inoculated with TuMV C3, while varying numbers of plants were infected (depending upon the families) when inoculated with other strains. The results imply that B 730 may be totally immune to TuMV C3 but not to other strains. This hybrid, in other words, is not genetically pure in its reaction to four strains of TuMV.

Out of 31 inbred lines included in either one or both screenings, 12 showed immunity to one or two strains, and the other five lines to all five strains, three of which were later confirmed by two confirmatory screenings. Table 11 summarizes the TuMV reaction and other important traits of the newly identified resistance sources and B 730. All of the three lines are directly or indirectly derived from accession B 141.

Table 10. Reaction of selected B 730 progenies to different strains of turnip mosaic virus.[z]

Progeny[y]	Inoculated with					Noninoculated Ck.
	C1	C2	C3	C4	C5	
B 730-10 x	0/20	1/22	0/24	2/17	4/14	0/23
B 730-10 M	1/22	1/21	0/19	6/21	3/23	0/23
B 730-16 x	3/24	3/24	0/24	4/22	4/24	--
B 730-20 x	0/18	2/19	0/19	5/15	2/17	0/17
B 96 (sus. ck.)	22/22	20/20	24/24	20/20	19/19	--

[z]Plants infected/plants inoculated. [y]x = selfed progenies; M = progenies obtained by pollination with pollen mixture of fifteen B 730 plants.

Table 11. Breeding nature and horticultural characters of sources of resistance to TuMV.

Source	Reaction[z] to					Breeding Nature	Heat Reaction[y]	Remarks
	C1	C2	C3	C4	C5			
B 730 progeny	I/S	I/S	I	I/S	I/S	F2s from an obsolete cv.	HS	
0-2	I	I	I	I	I	Inbred line	MT	Susceptible to soft rot
(0-2)/BC-2-9-3	I	I	I	I	I	Inbred line	"	"
(0-2)/BC-2-13-5-2	I	I	I	I	I	Inbred line	"	"

[z]I = immune, S = susceptible. [y]HS = heat sensitive; MT = moderately tolerant to heat.

Two of them were bred through a previous program for TuMV C1, where selections were done after artificial inoculations with the particular target strain, usually followed by field infection of naturally occurring TuMV strains. These lines will be utilized in future breeding programs to incorporate the resistance to tropical Chinese cabbage and to generate genetic information on the resistance.

Conclusion

B 730, a previously known source of resistance to all five strains of turnip mosaic virus was studied for genetic purity using its progenies. Thirty one inbred lines were also screened against each of the five TuMV strains. Results showed genetical impurity of B 730 with respect to TuMV resistance, except for its reaction to strain C3. O 2 and two other moderately heat tolerant inbred lines were found to be immune to all five known strains.

Breeding for Heat Tolerance and Cylindrical Head Shape

Introduction

In certain tropical countries, a strong preference for the cylindrical head shape has been one of the limitations in promoting AVRDC's tropical Chinese cabbage cultivars whose heads are generally round-shaped. As an attempt to solve this problem tropical inbreds had been previously crossed with heat-sensitive Michihili type cultivars having a cylindrical head, and they were advanced to the F2 generation in the 1984-1985 cool season. In 1985, these F2 families underwent a selection process for the cylindrical head shape and downy mildew resistance.

Materials and Methods

Forty four F2 families divided into four different batches went through *in vitro* screening for downy mildew resistance. Cotyledons were detached when fully expanded and placed on moist filter paper in petri dishes. Five ml of *Peronospora parasitica* inoculum with a density of 10^4 spores/ml was dropped on each cotyledon, and the petri dishes were incubated at 15°C with a photoperiod of 12 h of dim light.

Every family was replicated four times. A petri dish with five cotyledons served as a replication. B 14 was included as the standard check in each batch. After eight days of incubation, the spores on each cotyledon were washed into 1 ml of distilled water, counted under a microscope with a hemacytometer, statistically analyzed, and compared to the standard check of the same batch. The whole screening procedure was done by the Center's pathologists.

Five hundred plants in each of ten families preselected in the *in vitro* screening were transplanted on September 18 when seedlings were 21 days old. A susceptible cultivar, B 14, was planted in every third hill to increase inoculum pressure and serve as the standard for comparison. The whole experiment was encircled by two rows of the susceptible check. The field was kept moist by frequent sprinkler or furrow irrigation. Parental materials of all the families and a resistant check, B 639, were also included for comparison. Disease severity was scored on November 13 and the selection done on November 15.

Results and Discussion

Eight out of 44 families included in the *in vitro* test showed significantly lower spore counts than the check in each batch. All other families (except two with the least spore count in Batch II where no entry showed significant difference from the check) were discarded before being included in the following field trial (Table 12). All of the ten entries in the field screening showed significantly lower percentage of infected leaf area than the susceptible check. Disease severity was not uniform enough throughout the experiment to allow a fair comparison between the resistant check, planted at the corner of the experiment, and the families located at different distances; hence, the family means of disease severity was not statistically compared to that of the resistant check. A total of 134 plants was selected from five families based on general appearance and downy mildew resistance (Table 13). These plants will be utilized for further generation advancement and selection process.

Conclusion

To develop cylindrical heat-tolerant cultivars with downy mildew resistance, 44 F2 families of tropical X Michihili type Chinese cabbage were tested. For downy mildew resistance, the in vitro screening method was employed in preliminary selection of the families to enter the following field screening. One hundred and thirty four Michihili like plants free from downy mildew were selected from five families.

Table 12. Spore counts (10^4/cotyledon) of *Peronospora parasitica* in F2s selected for field evaluation from crosses between heat-tolerant and cylindrical materials after *in vitro* cotyledon inoculation.

Batch	Entry/ Pedigree	Spore Count in F2[z]	check	LSD.05
I	E-9/B 61	20.8*		
	E-9/B 86	29.0*	57.3	19.0
	J6-3/B 86	30.3*		
II	PL-1/B 86	39.0	49.3	NS
	R1-3/B 61	40.0		
III	U2-5/B 86	55.8*	84.5	26.7
IV	B 61/B 152	46.8*		
	B 61/B 175	29.5*	102.0	32.9
	B 79/B 152	40.8*		
	B 86/B 152	39.8*		

[z]Asterisks indicate that the number is significantly lower than that of the check, B 14, by batch

Table 13. Percent leaf area infected by Peronospora parasitica in selected crosses between heat-tolerant and cylindrical materials after field inoculation and number of selected plants from each family.

Family/ Pedigree	Infected Area in entries (A)	check (B)[z]	A/B (%)	B-A	No. of Sels.[y]
E-9/B 61	0.73	5.35	13.6	4.62**	29
R1-3/B 61	3.74	8.77	42.6	4.03**	27
B 61/B 152	5.40	8.95	60.3	3.55**	22
B 61/B 175	6.25	10.67	58.8	4.42**	29
B 79/B 152	6.10	12.96	47.1	6.86**	23

[z]The downy mildew spreader cultivar, B 14, planted together with the respective entry family also served as a check for comparison. [y]All selections are cylindrical in head shape. ** difference recognized by t test at the .01 probability level

Uniformity Improvement Program of OP Cultivars

Introduction

The AVRDC Chinese cabbage breeding program has developed quite a number of open-pollinated cultivars, some of which are warmly accepted in several countries for their good performance. However, they are widely dispersed in maturity, mostly two weeks or longer. In 1985, a program to attain uniform maturity was initiated with two OP cultivars, 77 M(3) 27 and 77 M(3) 35, both of which had shown good yield and a high level of heat tolerance and downy mildew resistance. Special care was taken to retain the original or a higher level of downy mildew resistance, in the course of the implementation procedure.

Materials and Methods

Two OP families were sown on August 29 and transplanted with checks for susceptibility and resistance to downy mildew (B 14 and B 639, respectively), and to heat (B 40 and ASVEG 1). B 14 was also used as a spreader of downy mildew spores by planting it on every third hill and two additional rows surrounding the experiment. Double-row beds, 150 cm apart from center to center, were used with a spacing of 50 cm between rows within beds, and 40 cm between hills. The field was maintained moist by frequent furrow or sprinkler irrigation to enhance downy mildew severity. Selection was done on November 15.

Results and Discussion

By the time most plants reached maturity, downy mildew infection had become reasonably high throughout the whole field. Consequently, it was possible to select resistant plants of a narrow maturity range, by discarding both late-maturing loose-headed plants and extremely early-maturing ones whose heads had already burst by selection time.

One hundred and fifty-three plants or 7.2% and 85 plants or 4.6% have been selected from 2,130 and 1,858 plants initially included in 77 M(3)-27 and 77 M(3)-35, respectively. Among them, 15 and 14 elite plants in 77 M(3)-27 and 77 M(3)-35, respectively, were chosen as maternal parents, while the rest will be used as pollen parents in the first cycle of maternal-line selection. Uniform appearance, in addition to the primary objective which is uniform maturity, was also another major consideration in the selection process.

Conclusion

A program was initiated to attain uniform maturity in two tropical open-pollinated cultivars, 77 M(3)-27 and 77 M(3)-35. One hundred and fifty-three downy mildew-free plants uniform in maturity and general appearance were selected from the former cultivar, and eighty-five from the latter. These selected plants will create the populations for the first cycle of maternal-line selection.

Cytosterility Backcross Program

Introduction

This program aims to transfer cytoplasmic male sterility (CMS) derived from radish and *B. juncea* to tropical Chinese cabbage. CMS is expected to be a simpler alternative to the complicated self-incompatibility system in hybrid seed production. This year, the backcross program was continued to select plants with less chlorosis and with better-functioning reproductive organs, as well as other improved characteristics wherever possible.

Materials and Methods

Seventeen different BP/4A families of radish cytoplasm and twenty-seven BC2-BC3 families of *B. juncea* cytoplasm were included. Three heat-tolerant, self-fertile lines, CT1-27, CT1-32, and 7252-1 were used as recurrent parents for the former group; and CT1-32, CT1-56, and B-18 for the latter group. Population size varied from 104 to 397 plants in the radish-derived CMS, depending upon different families. Population size of *B. juncea*-derived families, however, had to be limited from 1 to 101 plants, since backcrossing is still in the early stage without full recovery of fertility from interspecific hybridization.

Primary selection was made for normal-shaped families and individuals with less seedling chlorosis. Plants preselected in this way were examined for their floral structure, chlorotic symptoms, nectar gland development, and nectar secretion for further selection at the flowering stage. Flower- and nectar-related observations were done with five randomly chosen, fully developed fresh flowers in every individual plant. The scoring system for nectar gland development is shown below:

Size	Per unit gland inner	Per unit gland outer
None	0	0
Vestigial	2	1
Small	4	1
Normal	8	2

Scores given in this way will be a sum of 100 [= (8+2) x 2 glands x 5 flowers] in the plants where all examined five flowers have two normal-sized inner glands and two normal-sized outer glands. Different scores represented various degrees of development of different individual plants.

After discarding inferior plants based on the traits hitherto examined, the plants were bee-pollinated with their recurrent parents in the isolated screenhouses. Overall observations on setting rate and shape and size of pods were referred to in the final selection of the radish-ex CMS. Seed count per pod was also reflected wherever possible. In *B. juncea*-derived materials, pod and seed traits were rather neglected because of the importance of chlorosis and similarity to the recurrent parents in the early backcross generations.

Results and Discussion

Sixty-seven plants of 14 different radish-originated CMS families survived two preliminary selection steps, initially for leaf color or chlorosis in the seedling and bolting stages and next, for nectar gland development and secretion. Table 14 summarizes the characters of the final selections in comparison

Table 14. Leaf color, flower, and seed-set characters of radish-derived CMS backcross selections.

Recurrent Parent	Selection	Sdlg Leaf Color[z]	Chlorosis in Reproductive Stage[y]	Pod[x] set rate	Pod[x] size	Pod[x] shape	Nectar Gland dev. score[w]	Nectar Gland secretion[v]	Max. Seed Count/Pod[u]
CT1-27	84W12-6	DG	+	G	P	F	18	A	9
CT1-27	84W13-5	G	+	G	G	G	14	A	7
CT1-27	84W14-4	LG	+	G	E	E	59	A	10
CT1-27	84W16-1	DG	+	F	F	F	38	A	12
CT1-27	84W17-3	G	–	E	E	E	15	A	19
CT1-27	84W18-2	LG	+	E	E	G	12	A	19
CT1-27	84W18-7	G	+	E	E	E	62	A	18
CT1-27 (Recurrent)		G	–	G-E	G-E	G-E	(100)	A	29
CT1-32	84W20-1	DG	+ +	F	G	G	10	A	25
CT1-32	84W22-2	LG	+	F	G	G	12	A	16
CT1-32	84W23-2	DG	+	G	F	G	23	S	17
CT1-32	84W24-1	G	+	F	G	G	13	S	14
CT1-32	84W24-4	G	+ +	G	F	F	11	S	17
CT1-32	84W25-2	DG	+	P	P	P	6	S	14
CT1-32 (Recurrent)		DG	–	G-E	G-E	G-E	(100)	A	24
7252-1	84W27-1	DG	+	G	G	G	20	S	17
7252-1	84W27-6	LG	+	P	G	G	9	S	17
7252-1	84W27-7	G	+	F	F	F	7	S	7
7252-1 (Recurrent)		DG	–	G-E	G-E	G-E	(100)	A	25

[z]DG = dark green; G = green; LG = light green. [y] – = + + + + ; no chlorosis ~ very severe chlorosis. [x]Overall observation with scores of P (poor), F (fair), G (good) to E (excellent = normal). [w]100 for plants with flowers having two inner and two outer glands with normal size (five flowers/plant examined). [v]A = juice found in almost all flowers; S = juice found in some flowers; N = juice not found. [u]By bee pollination in the screenhouse.

with their respective recurrent parents. Leaf color had become normal, and chlorosis was not apparent in any selected plant. Nectar secretion was nearly regular in CT1-27 families, even though nectar gland development scores (12-62) were far below the theoretical maximum (= 100).

Pod size, shape, and set rate were also normal in most of CT1-27 selections, although seed-bearing capacity generally seemed to be a little lower than that of the recurrent parent. Therefore, these families are ready for the combining ability trials which will search for the desirable male combiners, provided that such recovered level is maintained, if not improved, in the majority of the following backcross generation. The other two groups (with CT1-32 and 7252-1 as recurrent parents) seemed to need more backcrosses to improve their nectar glands, as well as pod and seed sets.

Table 15 shows leaf color, chlorosis, flower structure, and nectary development of best selections from the *B. juncea* derived CMS backcross families. With a few exceptions, leaf color of backcross selections was lighter than that of the recurrent parents. Although chlorosis was generally severe, three and one selections with CT1-56 and B-18 as recurrent parents, respectively, showed very slight symptoms.

Petal size was still much smaller than that of the recipients, and many plants developed abnormal flowers. On the contrary, nectar gland development and secretion were not much different from those of the normal recipients. These selections will undergo further backcrossing for improved-flower structure and recovery of the characteristics of the recipients.

Conclusion

In order to develop a simpler and more stable hybrid breeding system alternative to self-incompatibility, 17 radish derived and 27 *B. juncea* derived CMS families underwent another backcross generation. Sixteen BP-4A plants from the former origin and twelve BC2-BC3 plants from the latter group were selected for less chlorosis, better nectary development, and/or pod and seed set to be used for further backcrossing.

Table 15. Leaf color, chlorosis, and floral characters of *B. juncea*-derived CMS backcross selections.

Recurrent Parent	Selection	Seedlg Leaf Color[z]	Chlorosis in Reprod. Stage[y]	Anther Structure[x]	Petal Size	Nectar Gland dev. score[w]	Nectar Gland secretion[v]
CT1-32	84W31-4	LG	+ +	P	.4N	65	A
CT1-32	84W32-4	LG	+ +	V	.4N	40	A
CT1-32	84W32-5	G	+ + +	V	.3N	22	A
CT1-32 (Recurrent)		DG	-	N	N	(100)	A
CT1-56	84W42-2	DG	–	V	.3N	37	A
CT1-56	84W43-1	DG	–	V	.2N	22	A
CT1-56	84W46-1	LG	+	V	.3N	51	A
CT1-56		DG	–	N	N	(100)	A
B-18	84W61-1	G	+ + + +	V	.5N	90	A
B-18	84W62-2	DG	+ + + +	V	.4N	100	A
B-18	84W62-7	LG	+ +	V	.3N	82	S
B-18	84W62-10	?	?	V	.5N	88	A
B-18	84W63-3	G	+ + +	V	.3N	10	N
B-18	84W64-7	G	+	V	.2N	20	N
B-18 (Recurrent)		DG	–	N	N	(100)	A

[z]G = green; DG = dark green; LG = light green. [y] – = + + + + : no chlorosis = very severe chlorosis. [x]P = petaloid; V = vestigial; N = normal. [w]100 for plants with flowers having two inner and two outer glands with normal size (five flowers/plant examined). [v]A = juice found in almost all flowers; S = found in some flowers; N = not found.

International Trials

In 1985, 1,724 packets of Chinese cabbage seed were distributed to 145 cooperators in 47 different countries. Most of the shipments included recently developed tropical open-pollinated (OPs) and/or F1 hybrid cultivars for trials in different growing environments. Reports from our cooperators are summarized as follows.

Australia. Mr. G. Nahrung included AVRDC hybrids in the autumn trial conducted in Gatton Redlands Horticultural Research Station in Queensland from April to July, 1985. AVRDC hybrids constituted the earliest maturing group with the firmest heads and the least *Alternaria* disease development (Table 16). Although plant weight was less than that of other cultivars developed for temperate conditions, all of them showed a potential for commercial growing without bolting in this area. Tipburn was a problem of the AVRDC materials.

Mr. R.A. Sarooshi of New South Wales Department of Agriculture sent a report published in a local newsletter of a trial planted in February, 1984. AVRDC Hybrids 58 and 59 reached maturity 35 days after transplanting with 1kg of head weight. They showed less tipburn than ASVEG 1. Two OP's, 77 M(2/3) 45 and 77 M(2/3) 46, also produced firm heads averaging 800 g in 35 to 41 days after transplanting.

Table 16. Performance of AVRDC hybrids in an autumn trial at the Gatton Redlands Horticultural Research Station, Queensland, Australia.[z]

Cultivar	Top Wt (kg)	Maturity (DAT)	Alternaria[y]	Head Firmness[y]	Soft Rot (%)	Tip-Burn
Hybrid 59	1.8	44	1	1.2	10	Moderate
ASVEG 1	1.3	42	1	1.2	3	Moderate
80-32	1.6	42	1	1	5	Moderate
80-33	1.4	44	1	1	15	Moderate
80-37	1.6	46	1	1	15	Moderate

[z]Sown on 11 April and transplanted on 8 May 1985. [y]Rated on a 1-to-5 scale, 1 for good and 5 for poor.

Costa Rica. Hybrid 59 was recognized as the best entry in yield and quality among ten heading cultivars of different sources in a trial by the Chinese Agricultural Mission in Costa Rica. This trial was conducted by Mr. S.H. Lai in the Mission from October 1983 to January 1984 when mean temperature was almost constantly around 22.5°C, with a daily fluctuation of 10°-12°C. Estimated yield of Hybrid 59 was 38.7 t/ha with a perfect harvest rate and a maturity of 39 days from transplanting.

El Salvador. Mr. Daniel Chen, one of our cooperators in El Salvador, C.A. tested ASVEG 1 and reported the result simply, "Excellent". It was sown on April 6, and heads of around 2 kg were harvested in the beginning of the rainy season (5 June) when other cultivars had never been successfully grown. Next year he will try ASVEG 1 in the middle of the rainy season from June to September.

India. Table 17 shows yield and other horticultural characters of the best performing AVRDC entries in a trial conducted by Dr. M.L. Pandita in Haryana Agricultural University, Hissar, Haryana, India. ASVEG 1 and two OPs, 77 M(2) 25 and 77 M(3) 40, produced the highest yield, and all the listed entries showed 100% harvest rate with no soft rot infection.

Japan. Messrs. Y. Suzuki and T. Ohtani at the Shizuoku Agricultural Experiment Station conducted a replicated summer trial using nine AVRDC hybrids with a local check sown on 18 July, 1984. AVRDC hybrids (80-83, 80-37, Hybrid #58, and ASVEG 1) matured 10 days earlier than the local check, Seikai, and produced firm heads 56 days after direct sowing. Harvest rate was 100% or nearly so with the estimated yield of 26.6 to 38.8 t/ha. Hybrid 80-37 was the highest in yield. These hybrids were, in texture, good for cooking with meat as 'Sukiyaki' and accepted favorably in the local market.

Table 17. Performance of the best AVRDC OPs and ASVEG 1 in a trial conducted at Hissar, Haryana, India.[z]

Entry	Yield (t/ha)	Maturity (DAS)	Harvest Rate (%)	Head Wt (g)	Soft Rot (%)
77 M(2)-25	66.5	74	100	1,175	0
77 M(3)-27	61.1	84	100	1,223	0
77 M(3)-40	65.5	69	100	1,309	0
ASVEG 1	68.2	74	100	772	0
B 189	54.7	69	100	554	0
B 40	40.6	69	100	612	0

[z]No statistical analyses were made because of the unequal number of replications in different entries.

In Nagasaki, two AVRDC open pollinated Chinese cabbage cultivars, 77 M(3)-26 and 77 M(3)-35, locally named Summer Nagasaki No. 1 and Summer Nagasaki No. 2, respectively, were recommended by the Prefecture Farmers' Cooperative of the region for summer production in August and September, 1985. The Cooperative also prepared and distributed a technical guidance sheet to the participating farmers regarding its cultivation.

Kampuchea. Dr. Brent Rowell, Vegetable Production Specialist in the Kampuchea Program of Church World Service has filed a report on a trial with AVRDC materials transplanted on February 7 and harvested on March 29, 1985. Because of improper water supply, his trial was not very successful. Six highest yielding entries, however, were selected for further replicated trials (Table 18). He also reported the favorable effect of straw mulching which was applied in one of the two replications in the trial.

Table 18. The best-performing AVRDC entries in a trial conducted in Kampuchea.[z]

Entry	Survival Rate at Harvest (%)	Yield[y] (kg/plot)
ASVEG 1	82	5.65
Hybrid 59	67	4.20
77 M(3)-26	72	4.00
77 M(3)-35	69	3.85
77 M(2/3)-29	63	3.65
77 M(3)-38	59	3.10

[z]Statistical analyses were not done because of different cultural practices (mulch vs. nonmulch) in two replications. [y]Plot size: 1.2 × 4.0 m

Niue Island. In a trial in Niue Island conducted by Mr. Felix Tafatu-Hipa, Department of Agriculture and Fishery, four AVRDC heat tolerant, open pollinated cultivars (77 M(3)-38, 77 M(3)-40, 77 M(2/3)-41, 77 M(2/3)-43) performed well. They grew vigorously and matured very fast. Their heads ranged from 1.5 to 1.8 kg in size despite insufficient water supply and were greatly favored in the local market. Year-round sowing of those cultivars seemed possible, but more so from January to July.

Philippines. The Philippine Outreach Program conducted a series of trials with two different sets of AVRDC Chinese cabbage from 1982 through 1984. Table 19 presents the yields and harvest rates of the promising entries. Hybrids 58 and 62 (ASVEG 1) had the most stable high yields attributed to high and stable harvest rates. Among the entries in the second set, three hybrids, 80-33, 80-13, and 80-32, showed similar results (Table 20). Although hybrid 8144 showed the largest head size, its yield was neither stable nor high because of high soft rot incidence. A similar trend was also observed in Hybrid 80-36. Late maturity of these two entries were probably responsible for the high soft rot incidence and low harvest rate.

USA. Alf Christianson Seed Co. conducted a commercial-scale seed production of ASVEG 1 in the spring season of 1985. The production was successful and the seed has proved its purity and germinability in the tests at AVRDC. Now, it has become easier for commercial growers to obtain tropical Chinese cabbage seed on a large scale.

Zimbabwe. Mr. M.D.S. Nzima in the Dept. of Research and Specialist Services, Ministry of Agriculture, Zimbabwe, conducted a simple trial with AVRDC Chinese cabbage cultivars from November 1984 to January 1985. Table 21 summarizes the performance of selected entries. The cultivar 77 M(2/3)-46 had the highest harvest rate and head weight in a short growing period. Two hybrids, 58 and 59, and 77M(3) 33 had also higher harvest rates and bigger heads than the other entries.

Table 19. Yields and harvest rates of AVRDC Chinese cabbage in trials conducted in four different seasons at POP, Philippines.[z]

Entry	Yield (t/ha)					Harvest Rate (%)				
	1982		1983		mean	1982		1983		mean
	WS	DS	WS	DS		WS	DS	WS	DS	
AVRDC 58	15.5	21.8	15.5	24.5	19.3	71	93	80	86	83
AVRDC 59	9.4	19.7	17.3	23.9	17.6	47	85	85	87	76
AVRDC 62	16.6	17.7	16.8	26.8	19.5	78	79	88	89	84
77 M(2)-25	11.9	20.8	16.3	18.3	16.8	54	89	77	85	76
77 M(2/3)-41	12.7	15.2	17.3	21.7	16.7	63	83	85	97	83
77 M(2/3)-43	11.0	20.7	13.3	24.1	17.3	56	83	52	87	70
B 189C1 (Check)	9.2	11.3	16.3	13.5	12.6	68	83	88	80	80

[z]Summary table provided without raw data from each replication. WS = wet season; DS = dry season.

Table 20. Yields and harvest rates of AVRDC Chinese cabbage hybrids in trials conducted in three different seasons at POP, Philippines.

Entry	Yield (t/ha)				Harvest Rate (%)			
	82 DS	83 WS	84 DS	mean	82 DS	83 WS	84 DS	mean
8144	6.8 c	11.6 a-d	28.7	15.7	22 d	55 b	70 bcd	49
80-6	17.4 ab	11.4 bcd	24.1	17.6	88 ab	85 a	88 abc	87
80-12	16.8 ab	11.3 bcd	19.4	15.8	90 ab	80 ab	75 abc	82
80-13	21.2 a	13.2 a-d	24.3	19.6	97 a	91 a	97 a	95
80-32	20.6 a	14.7 abc	29.6	21.6	93 ab	89 a	91 ab	91
80-33	23.8 a	16.5 a	26.1	22.1	92 ab	93 a	88 abc	91
80-36	12.3 bc	11.7 a-d	14.4	12.8	48 cd	53 b	43 d	48
80-37	18.9 ab	15.7 ab	24.3	19.6	95 ab	93 a	82 abc	90
80-38	17.9 ab	15.6 ab	30.0	21.2	78 ab	91 a	97 a	89
80-39	18.5 ab	8.4 d	28.8	18.6	75 bc	55 b	88 abc	73
B 189C1 (check)	19.5 ab	10.0 cd	15.3	14.9	97 a	91 a	43 cd	75
LSD.05	6.6	4.4	NS					

[z]Mean separation within columns by Duncan's multiple range test at the .05 probability level. DS = dry season; WS = wet season.

Table 21. Harvest rates and other horticultural traits of the best OPs and hybrids in a trial in Chiredzi Research Station, Zimbabwe.[z]

Entry	Days to Maturity	Harvest Rate (%)	Head Wt (g)
76 M(2)-20	51	79	1110
77 M(3)-27	53	74	1166
77 M(3)-33	55	89	1019
77 M(2/3) 46	51	93	1436
Hybrid 58	51	87	1261
Hybrid 59	52	90	1284
ASVEG 1	52	79	1152
Chinese Chihli (Ck)	68	16	1867

[z]No statistical analyses included with summarized data.

Chinese Cabbage Entomology

Diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) and cabbage webworm, *Hellula undalis* (Lepidoptera: Pyralidae) are the two principal pests of most of the economically important cruciferous crops in tropical and subtropical areas of the world. They are especially serious in Southeast Asia. During 1985 our research activities were confined to controlling them.

In Taiwan, diamondback moth infestation occurs during the cool, dry autumn and winter seasons; and cabbage webworm incidence takes place mainly during the wet summer. Since aphids are more serious on Chinese cabbage in Taiwan and attack it at the same time as the diamondback moth, it is not possible to do a reliable field study on the latter with Chinese cabbage as the host plant. Hence, we use common cabbage instead.

Screening Chinese Cabbage Accessions for Resistance to Cabbage Webworm

Introduction

During the 1984 preliminary screening of 133 Chinese cabbage accessions and related species, 19 entries were identified as having a moderate level of resistance. In summer 1985, 19 accessions were screened with the susceptible check ASVEG 1 in a second screening to confirm their resistance level and select ones which were consistently less damaged.

Materials and Methods

A 0.05-ha parcel of land was rototilled, applied with basal fertilizer, and worked into 1.5-m-wide raised beds. These beds were further divided into 10-m-long plots. Seedlings of each of the 20 accessions were raised in flats for one month. Forty seedlings of individual accessions were transplanted on each of four randomly selected plots, each plot representing one replicate. Ten days after transplanting, an undetermined number of cabbage webworm pupae were released in the field to augment ambient insect population and ensure uniform and heavy infestation to enable us to select truly resistant materials.

The crop was raised according to traditional cultural practices, except that no insecticide was applied. At three and five weeks after transplanting, we evaluated each accession by recording the number of webworm-infested and healthy plants. The cabbage webworm larva feeds on the growing point and the accumulation of frass and visible damage to the growing point are the common symptoms of its damage. The data on mean percentage of plant damage were analyzed by Duncan's multiple range test.

Results and Discussion

Plant damage ranged from 36.3% to 73.7% in the first observation and 1.1 to 31.9% in the second (Table 1). Certain accessions more damaged in the first were much less so in the second and

Table 1. Infestation of selected Chinese cabbage accessions by cabbage webworm during the second screening.[z]

Accession	Damaged plants (%)		Accession	Damaged Plants(%)	
	7-11-85	7-30-85		7-11-85	7-30-85
B74	73.7 a	3.9 ef	B776	59.8 abcde	5.8 def
B648	70.7 ab	13.0 bcdef	B130	55.5 abcdef	25.5 ab
B446	70.0 abc	3.6 ef	B26	55.2 abcdef	20.2 abcd
B439	69.1 abcd	4.9 ef	B30	52.6 bcdef	10.8 cdef
B642	69.0 abcd	8.3 cdef	B314	51.3 bcdef	4.6 ef
B315	68.7 abcd	3.6 ef	B775	50.2 cdef	20.9 abc
B627	64.5 abcd	31.9 a	B780	49.6 def	2.6 f
B180	63.9 abcd	10.0 cdef	B28	42.1 ef	18.1 abcde
B156	61.7 abcde	28.1 ab	B148	42.0 ef	29.2 a
ASVEG 1	61.4 abcde	10.0 cdef	B197	36.3 f	1.1 f

[z]Transplanting date = 6-19-85, plot size = 10 m x 1.5 m, no. of replicates = 4, design = RCBD. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test

vice versa. However, B197 was the least damaged in both evaluations. This accession will be evaluated in the field during summer 1986 to confirm its level of resistance.

Conclusion

Twenty selected Chinese cabbage accessions were screened in the field for resistance to cabbage webworm during summer 1985. One accession, B197, was the least damaged in two evaluations for webworm infestation.

Sex Pheromone Studies with Cabbage Webworm

Introduction

Cabbage webworm (CWW) is prevalent mainly during the hot and humid season in Taiwan. At present farmers use only insecticides to control this pest. Since its damage threshold is very low and prevalent during the rainy season, the farmers are forced to spray more frequently.

AVRDC joined a network of sponsored projects on sex pheromone sponsored by the National Science Council of Taiwan and conducted several preliminary experiments in summer 1985 to study various parameters of the use of sex pheromones for CWW control in the field. Since the synthetic sex pheromone chemical was not yet available, virgin female moths were used as a pheromone source.

Materials and Methods

All experiments were carried out at the AVRDC experimental farm on a 0.5-ha Chinese cabbage field where no insecticide was used. For insect mass-rearing, larvae were collected from the field and reared on Chinese cabbage seedlings in the laboratory. The moths readily laid eggs and the larvae fed on the seedlings. The pupae were collected, sexed, and used for the following experiments in the field.

Trap design. Three types of traps - water trough, sticky paper, and cones - were used. In the water trough and sticky paper traps, the virgin females were confined in a perforated plastic cup attached inside to the uppermost part of the trap. In the cone trap, the virgin females were placed in a glass tubing whose ends were covered with muslin cloth. The tubing was placed in the collector bottle. This trap was placed alternatively with the collecting jars above or below the cone.

The traps were placed in the field 0.5 m above the soil surface every afternoon after 1700 and the number of male moths captured were recorded for three consecutive days.

Trap height. The sticky paper traps holding 10 females were placed at 0, 0.5, 1, and 1.5 m above the soil surface. A minimum distance of 20 m was maintained between two adjacent traps. The number of male moths caught was recorded.

Pheromone concentration. Traps containing 1, 3, 5, 10, or 15, three-to four-day-old virgin females were placed 0.5 m above the soil surface in the Chinese cabbage field. A distance of about 20 m was maintained between two adjacent traps. The number of male moths captured over a four-day period was recorded.

Virgin female age. Traps containing 10 virgin females ranging in age from one to five days after emergence were placed 0.5 m above the soil surface. A distance of about 20 m was maintained between two adjacent traps. The number of male moths captured in each trap was recorded over a three-day period.

Results and Discussion

Many CWW male moths were captured in the water trough and sticky paper traps. The cone trap failed to attract any CWW moths. The sticky paper traps got more moths (37) than the water trough (29). Sticky paper traps were consequently deployed in all subsequent tests because of this effectivity and their ease in use.

Traps placed 0 and 0.5 m above the soil surface attracted a significantly greater number of insects (17.75 and 24, respectively) than the traps placed at 1.5 m (1.5). The 1 m-high trap had an intermediate number (12.75) of insects. A numerically greater number of insects were caught in the 0.5-m- high trap than in the 0 m height. In subsequent tests this trap height will be used.

The number of male moths captured increased as the number of virgin females per trap increased from 1 to 10. Their number decreased slightly with 15 females. Ten virgin females per trap appears to be the optimum number, and we are now using this number for monitoring all sex pheromone activities of CWW.

Four day old females produced the greatest amount of sex pheromones as evidenced by the number of CWW males caught in traps baited with them . The number of males attracted to younger females was also substantial, but this number decreased when five day-old females were used.

Conclusion

Preliminary studies on the sex pheromones of cabbage webworm were undertaken with virgin female moths as pheromone source. Based on these findings a sticky paper trap positioned at a height of 0.5 m will be used to study CWW control with synthetic sex pheromone. For comparison with naturally produced pheromone, 10 three- to four-day-old virgin females per trap will be used.

Screening Insecticides for Cabbage Webworm Control

Introduction

In Taiwan, cabbage webworm occurs from late April up to October, the warm period of the year. This insect poses a threat to the crop during the seedling stage. Insecticides are the most efficient and popular method of cabbage webworm control, but safer and more efficient ones, preferably with a different mode of action, must be found.

In this research, we studied seven different insecticides: CME-134 and IKI-7899 (two chitin synthesis inhibitors), H3 and H7 (strains of *Bacillus thuringiensis*), MK-936 (an avermectin insecticide), and triazophos (a popular organophosphorus insecticide).

Materials and Methods

This experiment was conducted in summer 1985 at the AVRDC experimental farm. Nine insecticides and one untreated control replicated four times were arranged in a randomized complete block

design. Field plot evaluation was carried out in 15 sq m of plot size, 4.5 m wide, and 3.3 m long. Forty-eight Chinese cabbage seedlings were transplanted in two rows per raised bed in each plot with a distance of 40 cm between two plants in a row.

Emulsifiable and wettable powder formulations were applied with 10 liter air pressure sprayers charged to 2.7 kg/cm² for each plot. For the majority of these insecticides, a 0.75 liter spray volume (50% of the designated quantity of active ingredient per unit area) was applied per plot (500 liters/ha) for the first three applications and 1.5 liters per plot (1000 liters/ha) later on.

Locally manufactured disposable nozzles were used. Each sprayer was individually calibrated with a stopwatch and, by using the time calibrations, specific volumes of spray could be accurately and uniformly delivered to each plot to ensure that the specified amount of active ingredient was applied.

The insecticide treatment started six days after transplanting and was repeated once a week, except in the first two weeks of transplanting when it was applied more often, and in the last two weeks before harvest when none was used. Both the number of larvae on plants and the number of webworm-damaged plants were recorded once a week, a day before every insecticide treatment. At harvest the total yield per plot was recorded. All data obtained from this experiment were analyzed by Duncan's multiple range test.

Results and Discussion

The results of the insecticide screening are shown in Table 2. IKI 7899, CME 134, and MK 936 gave significant webworm control over the untreated check from the beginning of insecticide application until harvest. IKI 7899 and MK 936 were consistently more effective at each observation interval than other chemicals. There was no significant difference between IKI 7899 applied at 37.5 or at 75 g a.i./ha. MK 936, an avermectin type compound, showed similar efficacy as IKI 7899 at practically each observation interval. This chemical is highly effective against many lepidopterous insects, including insecticide resistant strains of diamondback moth. CME 134, like IKI 7899, is a chitin synthesis inhibitor. It has a similar efficacy spectrum as IKI 7899, and it is more effective against diamondback moth than IKI 7899 which is, however, more superior than CME 134 for cabbage webworm.

Table 2. Evaluation of insecticides for control of cabbage webworm on Chinese cabbage.[z]

Insecticide	Rate kg a.i./ha	% of Larvae per 45 Plants			Percent of Damaged Plants per Plot			Yield (t/ha)
		7-15-85	7-22-85	7-29-85	7-15-85	7-22-85	7-29-85	
CME-134 15SC	0.0375	1.25c	10.00b	1.50bc	5.70c	7.28c	14.18c	27.57abc
CME-134 15SC	0.075	0.50c	2.25b	1.25bc	2.05c	4.65c	11.10cd	27.21abc
IKI 7899 5SC	0.0375	2.00bc	2.00b	0.00c	6.28c	5.25c	4.75cd	29.50ab
IKI 7899 5SC	0.075	0.00c	1.00b	0.00c	4.10c	3.08c	2.13d	30.01a
Bt h H7	0.5	8.50a	15.50b	5.75ab	25.03b	28.03b	39.13ab	25.47bcd
Bt H3	0.5	5.00abc	34.00a	9.75a	28.78b	38.53b	47.43a	21.80de
Toarow CT	2	2.25bc	4.00b	1.75a	8.83c	10.93c	29.53b	27.82abc
MK 936 1.8EC	0.018	1.00c	1.00b	0.25c	5.78c	4.74c	5.35cd	28.85abc
Triazophos 50EC	0.5	0.25c	1.50b	2.50bc	5.75c	6.83c	8.85cd	24.78cd
Control		7.00ab	38.00a	9.00a	41.15a	53.63a	44.98a	18.28e

[z] Cultivar: ASVEG 1; transplanting date: 6-26-85; dates of insecticide application: 2-5, 9, 16, 23, and 30 July 1985; sampling dates: 15, 22, and 29 July 1985; harvest dates: 2-12 Aug. 1985; plot size: 15 sq m; Bt = *Bacillus thuringiensis*. Data shown are means of three replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level.

Toarow CT, a toxin preparation from *B. thuringiensis* gave better insect control than *B. thuringiensis* strains H7 or H3. However, it must be pointed out that the amount of Toarow CT recommended and used in this test was four times greater than that of *B. thuringiensis*. Among two *B. thuringiensis* strains, H7 gave better protection than H3. The insect population in H3 treated plots was not much different than that in the control. As in the past tests, triazophos, the standard insecticide, gave satisfactory control of cabbage webworm.

Conclusion

Based on the results of this screening IKI-7899, MK 936, and CME-134 were superior to others in controlling cabbage webworm on Chinese cabbage. These insecticides have a mode of action different from that of the traditionally used organophosphorus, carbamates, or synthetic pyrethroids. These compounds are also known to control other insect pests of crucifers.

Development of Diamondback Moth on Various Host Plants

Introduction

Diamondback moth, is one of the most serious pests of cruciferous vegetables belonging to the genera *Brassica* and *Raphanus*. However, the insect shows a distinct preference for some crucifers, such as the common cabbage. It multiplies rapidly on the host of its choice. This study, therefore, investigated the host preferences of diamondback moth in relation to its growth and development.

Materials and Methods

The development study was conducted in the laboratory and greenhouse. Fourteen varieties embracing six cruciferous crops were planted in pots in the greenhouse. Seeds of these hosts were planted three times at weekly intervals. When the plants were four weeks old, the leaves were fed to the diamondback moth larvae.

In the laboratory, each petri dish (10 cm diam.) containing a moist filter paper had one host leaf on which were five diamondback moth eggs. Each host had five petri dishes. Seventy petri dishes were put in the growth chamber (25 °C, 80% RH, and 12 h daylight). Leaves were changed everyday. The length of larval period of each larva on each host was recorded by observing them every 4 to 6 h until the larvae became pupae. Each pupa was weighed on an analytical balance and the duration of pupal period was recorded, as was larval mortality.

The feeding study was done after the results of the development study were in. The purpose was to determine the leaf area consumption of each host by the larvae in different larval instars. The experiment was designed like the development study, but the leaf cuttings were not changed until the larvae turned into pupae. The leaf area was measured before and after the insects fed on the leaves. The amount of leaf area consumed by each larval instar was determined by subtraction.

Results and Discussion

Development of larval periods. The development periods of diamondback moth reared on various hosts were different. The development period of 1st instar larvae reared on *Brassica campestris* subsp. *pekinensis* and subsp. *napus*, were very short, 2.50 and 2.58 days, respectively; while that on *B.oleracea* var. *acephala* was longer, 3.75 days (Table 3). In the 2nd, 3rd, and 4th instars, the insects completed these stages in a short time on *B. juncea*, *B. campestris* var. *sarson*, *B. campestris* subsp. *rapifera* and subsp. *pekinensis*.

On these same instars, they developed for a very long time on *B. oleracea* var. gongylodes; *B. campestris* subsp. *parachinensis*, *B. oleracea* var. *acephala* and *B. o.* var. *botrytis*. On *B. o.* var. *gongylodes*, larval mortality in the 1st and 2nd instars was 56%, and so it was unacceptable to the diamondback moth larvae (Fig. 1).

Leaf consumption. In this experiment, the leaves of the various crucifers mentioned earlier were also used. In each larval stage, the insects ate different quantities of leaves. On each host plant, the quantity consumed by the insects at the same larval stage also differed (Fig. 2). Table 4 shows that the smallest leaf area eaten by five larvae at the 1st, 2nd, 3rd, and 4th larval stages were on *B. oleracea* var. *acephala*, *B. o.* var. *gongylodes*, *B. o.* var. *acephala*, *and B. o.* var. *gongylodes*, respectively.

Pupal weight. One hundred and forty pupae from this experiment were weighed for comparison. The average pupal weight was least in insects reared on *B. o.* var. *gongylodes* and the average pupal weight was highest in insects reared on *B. campestris* subsp. *pekinensis* (Table 5).

Table 3. Comparison of development periods of diamondback moth on various crucifers[z].

Host	Development Periods (days)						Total Mortality(%)
	1st ins	2nd ins	3rd ins	4th ins	prep st	pu st	
1. *B.c.* subsp. *pekinensis*	2.50 g	2.29 c	1.88 c	1.93 i	0.56 d	4.50 cd	32.00
2. *B.c.* subsp. *napus*	2.58 g	2.28 cg	2.19 cd	2.43 fg	0.66 bcd	4.43 d	12.00
3. *B.o.* var. *capitata*	2.67 fg	2.65 b	2.28 c	3.10 bc	0.75 ab	4.94 b	20.00
4. *B.o.*var.*italica*	2.67 fg	2.20 cd	2.19 cd	3.17 b	0.62 cd	4.64 cd	20.00
5. *B. juncea*	2.68 efg	1.89 ef	1.87 e	2.52 ef	0.70 bc	4.65 cd	0.00
6. *B.c.* subsp. *chinensis*	2.74 defg	1.75 f	2.00 de	2.09 hi	0.81 a	4.57 cd	28.00
7. *B.c.*var.*sarson*	2.76 defg	1.82 ef	1.61 f	2.23 gh	0.632 bcd	4.46 cd	0.00
8. *B.c.* subsp. *parachinensis*	2.94 cdef	2.72 ab	3.14 a	3.11 bc	0.69 bc	4.46 cd	28.00
9. *B.c.* subsp. *rapifera*	3.01 cde	1.94 ef	1.87 e	2.58 def	0.84 a	4.70 bcd	0.00
10. *R. sativus*	3.02 cd	2.20 cd	2.03 de	2.65 def	0.65 bcd	4.43 d	8.00
11. *B. narinosa*	3.14 c	2.02 de	2.15 cd	2.79 de	0.62 cd	4.53 cd	8.00
12. *B.o.* var. *botrytis*	3.22 bc	2.61 b	2.56 b	3.65 a	0.702 bc	4.72 bc	44.00
13. *B.o.* var. *gongylodes*	3.52 ab	2.91 a	2.62 b	3.64 a	0.61 cd	5.58 a	56.00
14. *B.o.* var. *acephala*	3.76 a	2.61 b	2.99 a	2.86 cd	0.68 bc	4.44 d	40.00
CV (%)	18.78	16.99	18.83	17.40	26.51	9.33	

[z]Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test; rearing conditions: 25°C, 80% RH, 12 h daylight; ins = instar; prep st = prepupal stage; pu st = pupal stage.

Table 4. The consumption of some cruciferous foliage by the diamondback moth at different larval stages[z]

Host	Leaf Area (cm^2) Consumption by Different Larval Stages			
	1st instar	2nd instar	3rd instar	4th instar
B.c. subsp. *pekinensis*	0.64 a	2.08 ab	6.15 b	14.09 a
B.c. subsp. *napus*	0.65 a	1.71 de	5.64 d	10.01 e
B.o. var. *capitata*	0.27 c	0.68 g	2.09 hi	5.02 i
B.o. var. *italica*	0.34 bc	0.68 g	2.26 h	9.72 f
B. juncea	0.76 a	2.25 a	6.03 b	12.12 b
B.c. subsp. *chinensis*	0.62 a	1.76 de	6.35 a	11.52 b
B.c. var. *sarson*	0.58 ab	2.00 bc	4.51 f	9.04 g
B.c. subsp. *parachinensis*	0.54 ab	1.83 cd	5.83 c	10.27 d
B.c. subsp. *rapifera*	0.79 a	2.12 ab	5.15 e	14.00 a
R. sativus	0.65 a	1.45 f	3.06 g	7.90 h
B. narinosa	0.77 a	1.69 e	4.62 f	9.99 e
B.o. var. *botrytis*	0.61 a	0.77 g	2.06 i	8.94 g
B.o. var. *gongylodes*	0.22 c	0.36 h	2.06 i	4.72 j
B.o. var. *acephala*	0.17 c	0.63 g	2.03 i	7.77 h
CV (%)	33.28	9.58	3.26	1.37

[z]Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test (5 larvae, 25°C, 80% RH, 12/12 daylight).

Table 5. Consumption of leaf and pupal weight of diamondback moth on various crucifers.

Host	Consumption of Leaf Area (cm^2/larva)	Pupal Weight[z] (mg)	Sex Ratio F:M
B.c. subsp. *pekinensis*	4.59	5.8 a	3:7
B.c. subsp. *napus*	3.72	5.0 bcde	1:4
B.o. var. *capitata*	1.61	4.9 cde	2:3
B.o. var. *italica*	2.60	4.7 e	2:3
B. juncea	4.23	5.5 abc	3:7
B.c. subsp. *chinensis*	4.05	5.5 ab	2:3
B.c. var. *sarson*	3.23	5.4 abcd	1:4
B.c. subsp. *parachinensis*	3.71	4.6 e	3:7
B.c. subsp. *rapifera*	4.41	4.8 de	2:3
R. sativus	2.61	5.0 bcde	2:3
B. narinosa	3.41	4.6 e	2:3
B.o. var. *botrytis*	2.47	4.7 e	3:2
B.o. var. *gongylodes*	1.47	3.5 f	7:3
B.o. var. *acephala*	2.12	4.5 e	1:4
		CV (%) = 13.5727	

[z]Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

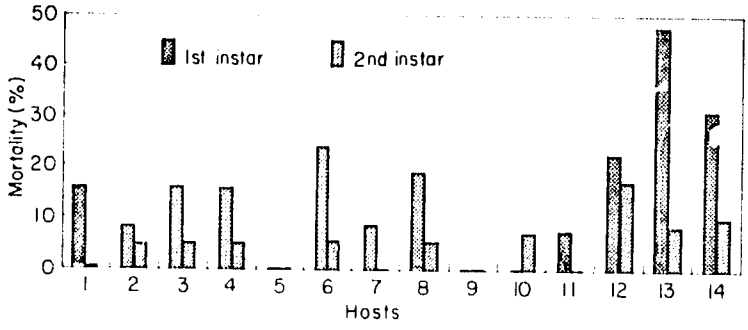


Fig. 1.
Mortality of 1st- and 2nd-instar larvae of diamondback moth reared on various hosts. (See Table 3 for host list.)

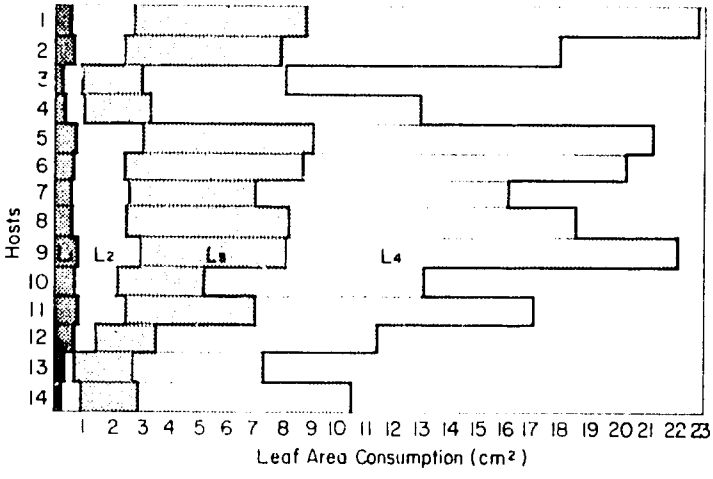


Fig. 2.
Leaf area consumption of various instars of diamondback moth larvae fed on various hosts. (See Table 3 for host list.)

In addition, there was positive significant correlation between pupal weight and leaf consumption (Fig. 3), but a negative relationship between pupal weight and development period (Fig. 4). The speed of development and feeding rate of this insect varied widely with the crucifer species. With leaves of *B. oleracea* var. *gongylodes* and *B. o.* var. *acephala*, the larvae grew slowly at 1st and 2nd instars and suffered high mortality.

The larvae, however, could complete their life cycle on all crucifers. This indicates that the leaves of all plants are of similar nutritional value. The efficiency of food utilization at the early instars was certainly of interest. The larvae's speed of development and feeding rate on *B. o.* var. *gongylodes* and *B. o.* var. *acephala* were significantly different from those in other crucifers. The pupal weight of insects fed on the two crucifers was very low.

It means that these crucifers are less suitable for the diamondback moth larvae than the other crucifers. It can also be concluded that pupal weight is closely related to larval consumption of host leaves but not to larval development. On less consumed host leaves, the insect's larval period was longer. It is expected that the next insect generation would be weak owing to reduced pupal weight.

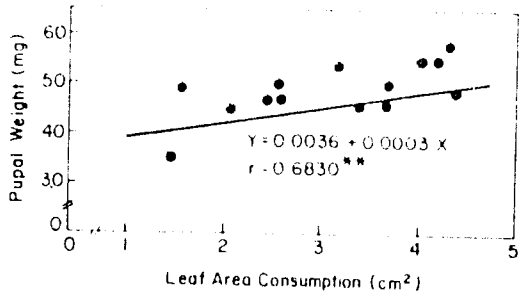


Fig. 3.
Correlation between leaf area consumption (in larval stage) and pupal weight of diamondback moth.

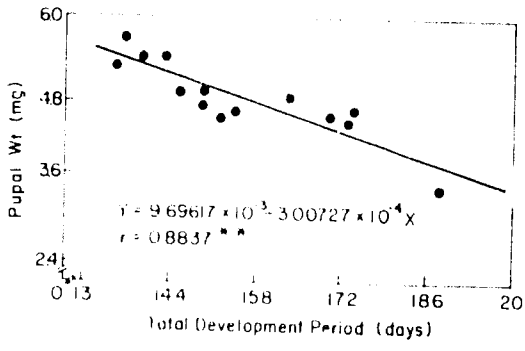


Fig. 4.
Correlation between larval development period and pupal weight in diamondback moth.

Conclusion

B. juncea, *B. campestris* var. *sarson*, *B. campestris* subsp. *rapifera* and subsp. *pekinensis* were the most preferred hosts. The larvae consumed more foliage of these crucifers, completed the larval stage in less time, and had heavier pupae. *B. cauloraipa* and *B. oleracea* var. *acephala* were the least accepted hosts. The larvae fed on these species consumed less foliage, had a longer larval stage, and produced the lightest pupae.

Oviposition Behavior of Diamondback Moth

Introduction

As a result of intensive insecticide use, the diamondback moth (DBM) has become resistant to most organic insecticides, and thus, it has become very difficult to control. Other methods of control,

therefore, are needed. At AVRDC, it was observed that sprinkler irrigation reduced DBM damage and increased cabbage yield when it was applied in the afternoon, thus, disrupting the moth's flying and mating activities and reducing its population.

This study went further to determine the DBM's oviposition period in order to time the application of the sprinkler irrigation at the peak of the egg laying activity. The moths invariably lay eggs on the upper leaf surface, making it easy to wash them away in the act of oviposition.

Materials and Methods

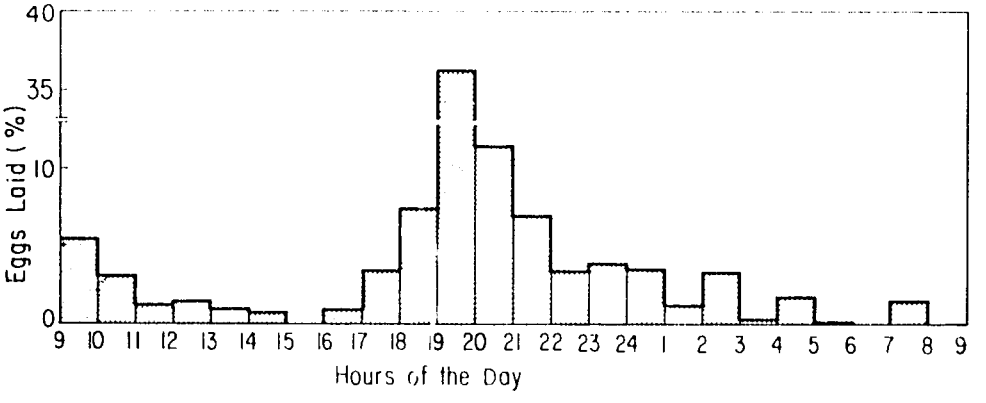
This experiment was done in the laboratory. Several Chinese cabbage seedlings of the same size planted in 5 cm wide plastic pots were selected. These seedlings were grown in the greenhouse and were free of DBM infestation or eggs. We used three nylon net cages 45 x 45 x 50 cm in size. Each cage represented one replicate. We released 200 DBM adults in each cage.

On the hour each hour throughout the day (24 h), we placed two Chinese cabbage seedlings in each cage. The seedlings were maintained inside the cages for one hour, after which, they were replaced with a fresh set of seedlings. The number of eggs on the upper and lower leaf surfaces and on the stems of the replaced seedlings were counted.

Results and Discussion

The results of the hourly egg laying on the Chinese cabbage seedlings are presented in Fig. 5. The total number of eggs laid in 24 h were recorded, and the number of eggs laid in any 1 h was expressed as a percentage of the total. Most of the eggs (65%) were laid between 6:00 and 10:00 P.M. with the peaks (36%) between 7:00 and 8:00 P.M. Of the total of 896 eggs counted, 60% were on the upper leaf surface, 37% on the lower leaf surface; and 3%, on the stems (Fig. 6).

DBM prefers to lay eggs on the upper surface, thus, making them vulnerable to sprinkler



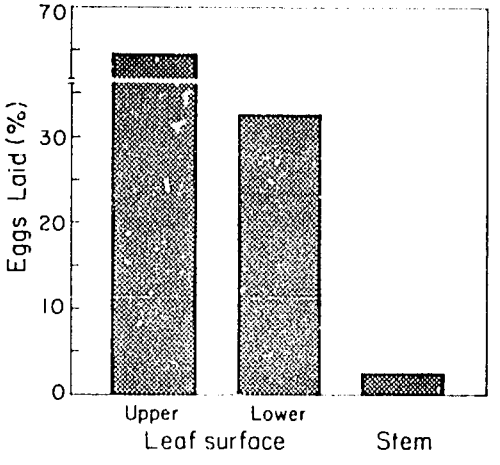


Fig. 5.
Periodicity of diamondback moth ovipositions.

Fig. 6.
Distribution of diamondback moth eggs in Chinese cabbage seedlings.

irrigation or the rain. So sprinkler irrigation must be applied between 7:00 to 8:00 P.M. when most of the eggs and the females are on the upper surface of the leaves. Since darkness seems to trigger DBM oviposition, egg-laying time will vary from season depending upon sunset time.

Conclusion

In a laboratory test with fresh Chinese cabbage plants, the DBM female laid most of its eggs between 7:00 and 8:00 P.M. Sixty-percent of the eggs were laid on the upper leaf surface; 37%, on the lower leaf surface; and 3%, on the stems. So, sprinkler irrigation must be applied at this time in order to catch the insect at its most vulnerable number and period.

Influence of Trichome Density on the Oviposition of Diamondback Moth on Chinese Cabbage Leaves

Introduction

Although in the field, common cabbage suffers greater diamondback moth (DBM) damage than Chinese cabbage, recent AVRDC research has indicated that the adult females prefer Chinese cabbage over common cabbage for oviposition. It is possible that Chinese cabbage has certain physical or physiological characters that make it more attractive.

Trichomes on the leaf surface of other crops influence the oviposition of many lepidopterous insects. So, it was felt that there might be some relationship between trichome density on the leaf surface of Chinese cabbage and oviposition.

Materials and Methods

This work was conducted in the greenhouse. Four cultivars were selected with four different trichome densities: B 288, B 777, New King, and ASVEG 1. Seeds of these accessions were planted in small plastic pots and allowed to grow for four weeks, after which, one pot of each accession was placed inside a cage (0.5 x 0.5 x 0.5 m). Ten such cages, each representing one replicate, were prepared.

Fifteen pairs of newly emerged adults were released in each cage and the number of eggs laid on the leaves were recorded on the fourth and fifth day. Past literature indicates that the percentage of copulating adults and the number of eggs laid on the fourth and fifth days after emergence are high.

Ten leaves from each accession were used for the trichome density study. Only the fourth leaf from each plant was selected. The number of trichomes on the upper and underside of four randomly selected 3 mm x 3 mm leaf areas were counted. The mean number of trichomes for each leaf of each cultivar was calculated.

Results and Discussion

Table 6 shows the trichome density of each Chinese cabbage accession and the number of eggs laid. The number of eggs on each plant varied considerably. The analysis of data by Duncan's

Table 6. Trichome density and oviposition of diamondback moth on four Chinese cabbage cultivars.[z]

Cultivar	Number of Trichomes/ 3 x 3 mm Area	Number of Eggs on Leaves
ASVEG 1	1.0250 d	22.2000 b
New King	5.6000 c	35.3000 ab
B 777	8.2500 b	40.5000 a
B 288	11.3750 a	44.9000 a
CV (%)	53.2432	50.5727

[z]Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

multiple range test showed that there were significant differences in egg number among varieties. The figures on the table also demonstrate that there is a direct relationship between trichome density and number of eggs deposited. This correlation is highly significant and positive (r = 0.9865 **) between trichome density and egg number (Fig. 7).

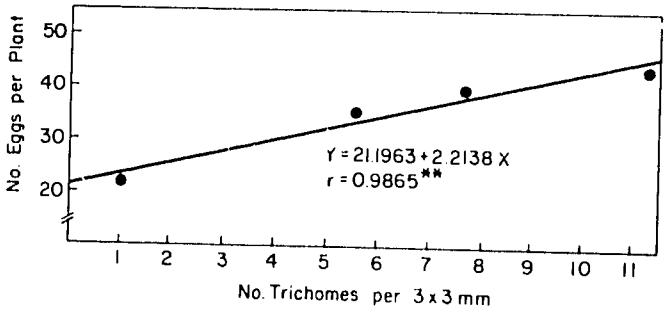


Fig. 7.
Correlation of trichome density and diamondback moth oviposition on Chinese leaves.

Conclusion

The results of this study indicate that trichomes on the leaf surface are a factor in the adult female's choice of leaf surface for oviposition. The trichomes probably act as hook or support for the insect and the eggs. Further studies are needed in order to understand better the role of trichomes in the oviposition of diamondback moth. The results of this study suggest that the cultivation of glabrous Chinese cabbage cultivars may help in reducing DBM insect population, although it may not be effective enough.

Intercropping for Diamondback Moth Control

Introduction

In an earlier study in 1983-84, we observed that among 54 crops used in an intercropping study, dill, garlic, and tomato reduced diamondback moth (DBM) infestation and did not cover the common cabbage plants. This favorable result on DBM infestation seems to be related to possible repellent properties possessed by these crops. This study is a confirmatory test on a larger plot size and three planting dates with garlic and tomato as intercrops of the main crop, common cabbage, to achieve a practical and economical control of diamondback moth.

Materials and Methods

A 0.5-ha parcel of land was rototilled, applied with basal fertilizers, and worked into 0.75-m-wide beds. The beds were further apportioned into thirty-two, 9 m x 10 m plots. Tomato and garlic were separately intercropped with common cabbage in 16 plots each. In both cases, the planting pattern was identical as follows:

- In the first group of four plots, tomato or garlic was planted on 10-m-long alternate beds four weeks ahead of cabbage which was later transplanted between two rows of tomato or garlic.
- In the second group of four plots, tomato or garlic was planted on 10-m-long alternate beds two weeks ahead of cabbage which was later transplanted between two rows of tomato or garlic.
- In the third group of four plots, tomato or garlic was planted on alternate beds simultaneously with cabbage which was planted between two rows of tomato or garlic. In these first three groups, garlic was also planted between two adjacent cabbage plants in each row.
- The fourth group of four plots was planted to cabbage only.

A month before the common cabbage was transplanted, it was also planted along the four sides of the experimental area where DBM adults were released. This treatment served as the source of DBM infestation for the experiment.

At intervals during the season, common cabbage in the experimental plots was observed for DBM infestation. Twenty plants were selected at random and the number of larvae and pupae was recorded. In the intercrop treatment only five rows in each plot were planted to cabbage, and so, at harvest we recorded the yield of marketable heads of only these rows in each plot, including the check plot. The insect count and yield data were analyzed by Duncan's multiple range test.

Results and Discussion

The tomato intercrop did not have any significant influence on diamondback moth infestation (Table 7). Only one observation showed that DBM infestation was significantly lower in cabbage with the tomato intercrop than in cabbage as a sole crop. In six remaining observations there was either no significant difference or there were more DBM larvae and pupae in the intercropped cabbage than in the sole crop.

On the contrary, except for the first observation, the garlic intercrop significantly reduced DBM infestation of common cabbage in all evaluations (Table 7). Insect infestation was lesser when garlic was planted earlier. The garlic odor probably stopped the diamondback moth from approaching the cabbage plants. Garlic intercropping, however, affected cabbage yield. Although yield was not significantly decreased in the later garlic planting, it significantly reduced cabbage yield when garlic was planted four weeks earlier.

Conclusion

Garlic as an intercrop reduced DBM infestation in common cabbage more effectively than tomato. However, it reduced cabbage yield considerably when it was planted four weeks earlier. This needs to be investigated further. Spacing or pattern of garlic planting can be modified to achieve insect control without influencing cabbage yield. Such planting can be used in conjunction with other control measures, such as the use of *Bacillus thuringiensis* and insect growth regulators.

Biological Control of Diamondback Moth

Introduction

In July 1984 we imported a hymenopterous parasite, *Diadegma eucerophaga* (Hymenoptera: Ichneumonidae) from Indonesia in order to release it in the farmers' fields to control diamondback moth (DBM) which is the most serious pest of crucifers in Taiwan and elsewhere. The parasite was raised on diamondback moth larvae in the laboratory. This study tested the parasitism potential of this insect in the field.

Materials and Methods

A 40 x 45 m parcel of land away from areas of frequent insecticide use was rototilled and worked into beds 1.5 m wide. Common cabbage seedlings were transplanted on the beds in two rows set 40 cm apart. The area was later divided into three parcels 40 x 15 m each and was enclosed in a 1.5-m-high nylon net screen. Three weeks after transplanting, 250 diamondback moth cocoons were introduced in the first two cages; the third cage was maintained as an insect-free check. Starting a week after the DBM release, *D. eucerophaga* adults were periodically introduced into one of the two cages with diamondback moths.

We recorded the extent of parasitism by collecting third to fourth instar larvae and raising them in the laboratory to observe the pupae. Parasitized diamondback moth larvae were killed just before the pupal stage and the *D. eucerophaga* came out and spun its own cocoons. The number of parasite and DBM cocoons were recorded and the parasitism percentage was calculated. At harvest we chose at random six 5 x 1.5 m areas in each cage, harvested all cabbage heads there, and weighed the marketable yields.

Table 7. Influence of tomato and garlic intercropping on the infestation of common cabbage by diamondback moth.[z]

Time of Intercrop Planting	No. Diamondback Moth Larvae + Pupae/20 Plants on							Yield (t/ha)
	2.22.85	3.1.85	3.7.85	3.4.85	3.22.85	3.27.85	4.2.85	
Tomato								
A. 4 weeks earlier	130.8 a	206.3 a	301.0 a	89.0 b	172.5 a	158.5 a	78.3 a	23.3 a
B. 2 weeks earlier	101.3 a	206.3 a	257.8 ab	106.3 b	149.0 a	154.3 a	67.8 ab	21.7 a
C. Simultaneously	109.3 a	194.8 a	272.5 a	186.8 a	166.3 a	112.8 a	40.3 b	23.6 a
D. No intercrop	94.8 a	194.3 a	155.0 b	209.3 a	188.0 a	128.8 a	38.0 b	24.5 a[y]
	2.28.85	3.7.85	3.14.85	3.2.85	3.28.8	4.3.85		
Garlic								
A. 4 weeks earlier	170.7 ab	213.0 c	137.0 c	89.8 c	86.0c	44.0b		18.9 c
B. 2 weeks earlier	158.5 a	22[illegible] b	177.3 c	98.5 c	122.8bc	46.5b		21.9 bc
C. Simultaneously	167.0 ab	293.7 b	273.5 b	175.8 b	168.5ab	70.8ab		26.4 a
D. No intercrop	141.0 b	368.3 a	384.5 a	260.0 a	222.8a	93.0a		23.5ab[y]

[z]Common cabbage cultivar [illegible] cross, common cabbage transplanting dates 1.4.85 (tomato), 11.7.85 (garlic), plot size 10 m × 8.[illegible] m, no replicates, 4, design RCBD, harvest dates 4.10.85 (tomato), 4.11.85 (garlic). Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test. [y]Yield of five out of 11 rows.

Results and Discussion

Diamondback moth infested the cabbage plants readily and its pest activity was present throughout the crop season. The parasite readily infested the diamondback moth larvae and laid eggs in them. Average parasitism was only 13.1% about a month after parasite release but reached 65.4% just before harvest.

The yield response of cabbage raised under three regimes of diamondback moth population is summarized in Table 8. When *D. cucerophaga* was released in cages with diamondback moths, cabbage yield increased significantly. The yield in the cage with parasites was double that in the control cage with only diamondback moths. In the cage without introduced diamondback moths, the yield was significantly greater than the above two treatments.

Conclusion

In a large enclosed area in the field, *Diadegma cucerophaga* successfully parasitized diamondback moth larvae. The parasites increased cabbage yield significantly above that of the control plot where an equal number of DBM were released.

Table 8. Yield response of cabbage infested by diamondback moth with and without parasites.[z]

Diamondback Moth Status	Yield (t/ha)
Only Diamondback moth released	7.67 c
Diamondback moth + parasite	14.83 b
No insect released	30.93 a

[z]Planting date 1.16.85, DBM released 2.7.85, *D. cucerophage* released 2.14.85 to 3.4.85, harvest date 4.3.85. Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Biological Control of Diamondback Moth in Farmers' Fields

Introduction

As a result of intensive insecticide use, the diamondback moth (DBM) has become resistant to practically all insecticides presently being used. The farmers' indiscriminate use of insecticide results

in yet higher level of resistance, exposes farmer and consumers to pesticides, and degrades the environment. In 1984, AVRDC imported a larval parasite, *Diadegma cucerophaga*, which is specific to diamondback moth and, after some tests initiated a mass release in the farmers' field.

Materials and Methods

Mass-rearing of parasites. The host insect, the diamondback moth, was reared initially on common cabbage plants or rape seedlings in the laboratory. A large number of cocoons were collected and placed in 0.5 x 0.5 x 0.5 m screen cages. The emerging insects were allowed to oviposit on potted cabbage seedlings for one day. The cabbage seedlings with eggs were maintained in the greenhouse for five days during which the eggs hatched into first instar larvae.

These seedlings with the larvae were then placed for two days in a 0.5 x 0.5 x 0.5 m cage containing a large number of *D. cucerophaga* adults provided with honey smeared on a sheet of plastic paper for food. These adults readily laid eggs inside the DBM larvae. The cabbage plants were removed and maintained in a large cage until the larvae pupated. The parasitized cocoons were collected for field release.

The *Apanteles plutellae* parasite was collected from a Chinese cabbage field in Tuchu township and reared on diamondback moth larvae. The rearing procedure is essentially the same as that of *D. cucerophaga* except that, instead of potted large cabbage plants, one week old rape seedlings raised on vermiculite in plastic containers (5 cm diam., 2 cm high) were used.

The seedlings were exposed for one day to a large number of diamondback moth adults for oviposition. After the eggs hatched into first instar larvae, they were exposed to *A. plutellae* adults in a cage (0.5 x 0.5 x 0.5 m) for oviposition. The parasitized larvae were transferred to a fresh lot of rape seedlings, and the *A. plutellae* cocoons were collected for release in the field.

Parasite release. With the help of the Tuchu Vegetable Growers Association we selected a 9 ha area owned by 23 farmers who grew cauliflower and broccoli. Eight release stations were established. Each station consisted of a perforated wooden box mounted on a 1 m high support. A large number of parasitized cocoons were placed inside each station once every week starting in early August.

Once every two weeks, 500 g of Bactospeine, a *Bacillus thuringiensis* formulation were distributed free of charge to each farmer to protect their crop against other lepidopterous pests such as cabbage looper, tobacco cutworm, cabbage butterfly, and cabbage webworm. Meetings with all farmers were held once every two weeks to explain the purpose and benefits of DBM biological control and the proper use of *Bacillus thuringiensis*. During the meetings we also answered farmers' queries about their insect pest problems.

Observations on parasitism. Starting early November we sampled the whole area periodically by collecting at random 100 to 150 3rd to 4th instar diamondback moth larvae, dissecting each, and recording the parasite larvae feeding within.

Results and Discussion

Until 18 December, we released about 9,000 cocoons of *D. cucerophaga* and 1,400 of *A. plutellae* over the area. Soon after emergence, the adults moved out and were observed searching for diamondback moth larvae throughout the field. Because no chemical insecticides were used, the native parasite, *A. plutellae*, started infesting diamondback moth larvae. These parasites were collected, mass-reared, and released back in the field.

The results of the rate of parasitism of diamondback moth by each of the two parasites are summarized in Table 9. A month after the first release, the parasites started infesting DBM larvae. The parasitism of *D. cucerophaga* increased from 0% to 46% and that of *A. plutellae* from 0 to 10.6% in one month. This rate is constantly growing with a greater and greater proportion of *A. plutellae* doing the parasitism. This level of parasitism is inadequate to give complete DBM control; nonetheless, in combination with *B. thuringiensis*, DBM infestation was under reasonable control without resorting to chemical insecticides.

Table 9. Rates of parasitism of diamondback moth by two larval parasites.[z]

Observation Date	Parasitism (%) by *D. eucerophaga*	*A. plutellae*	Total Parasitism (%)
11-5-85	0	0	0
11-12-85	0	0	0
11-18-85	12.2	3.6	15.8
11-25-85	2.0	5.0	7.0
12-3-85	12.6	3.5	16.1
12-11-85	12.8	9.6	22.4
12-18-85	16.3	10.6	26.9

[z]Location: Luchu township in Kaohsiung county.

Some farmers reported unusually large sizes of cauliflower heads and the absence of any DBM larvae in broccoli heads. This level of control was never achieved in the past despite drenching with insecticide cocktails.

The following problems were encountered in the course of the research.

- It is very difficult to convince farmers not to use chemical insecticides despite their unsatisfactory results in pest control. Cauliflower growers also tend to drench flower heads for the market with insecticide mixtures.
- Mass rearing of parasites should be streamlined to produce a maximum number of parasite cocoons in the shortest possible time. At times unexpected large-scale mortalities occur because of diseases.
- Although we released a large number of *D. eucerophaga* and observed the larvae within the DBM larvae, we have not yet seen the *D. eucerophaga* cocoons. This will require continuous release of this parasite until they are established.

Conclusion

Attempts are being made to control diamondback moth by a mass release of two of its parasites, together with the application of *Bacillus thuringiensis*, in farmers fields in Luchu township. This combined approach gave effective DBM control without the use of chemical insecticides. This program is now being expanded to other areas.

Screening of Insect Growth Regulators and Biological Insecticides for Diamondback Moth Control

Introduction

The indiscriminate use of insecticides has made diamondback moth (DBM) resistant to practically all chemicals presently being used. It has also killed beneficial predators and parasites which tend to be more sensitive to the insecticides than the host insect. As a result, the DBM problem has become even more serious than it was before the widespread use of chemicals.

Recently, insect growth regulators, a new class of chemicals which are toxic only to caterpillar pests but safe for their natural enemies, have been synthesized and registered in various countries. These chemicals are potentially useful in an integrated control of various caterpillar pests. This study tested some of these chemicals, along with various strains of a well known biological insecticide, *Bacillus thuringiensis*, to control DBM on common cabbage.

Materials and Methods

The procedures were identical to the ones described in our publication on vegetable pest control.[4] In brief, the study included nine insecticides and one untreated check. Each treatment had four replicates

[4] Talekar, N. S. 1986. Vegetable pest control: insecticide evaluation tests. AVRDC, Shanhua, Tainan, Taiwan.

arranged in a randomized complete block design. Designated common cabbage plots (4.5 m x 3.3 m each) were sprayed (with an air-pressurized sprayer) with each chemical once a week. Spraying was initiated from about two weeks after transplanting and discontinued a week before harvesting.

Insecticide efficacy was evaluated at intervals usually a day before the next insecticide application. At each interval, the number of DBM larvae and pupae found in randomly selected 20 plants in each plot was recorded. Infestation of cabbage worm *Pieris rapae crucivora* (Lepidoptera: Pieridae) was also quite serious, hence, we also applied the same procedure. At harvest, the yield of marketable cabbage heads of all plants in each plot was recorded. Insect count and yield data were analyzed by Duncan's multiple range test.

Results and Discussion

The results of the efficacy of insect growth regulators (IGR) and cabbage yield are summarized in Tables 10 and 11. CME-134 at both 37.5 g and 75 g a.i./ha and IKI-7899 at 50 g a.i./ha gave excellent control of DBM (Table 10). Among the remaining IGR compounds (DU-31922, DU-415155 and Dimilin), DU-31922 at 70 g a.i./ha gave satisfactory control of DBM.

Our standard chemical, profenofos, did poorly. Apparently DBM has developed a resistance to it. All chemicals gave good control of cabbage worm (Table 11). This insect is only an occasional pest and is quite sensitive to insecticides.

The results of the efficacy of Bactospeine, a commercial *B. thuringiensis* formulation, and two new strains, H7 and H3a3b, of the same organism, are shown in Table 12. Both strains at dosages of 0.5 to 1.5 kg product/ha gave superior control of DBM than Bactospeine, but this could be due to the higher dosage rates used.

Conclusion

In an insecticide screening test two insect growth regulars, CME-134 and IKI-7899, gave excellent control of DBM and significantly increased the yield in cabbage. Two strains, (H7 and H3a3b) of *Bacillus thuringiensis* also gave satisfactory control of DBM and significantly increased cabbage yields.

Table 10. Evaluation of insecticides for the control of cabbage worm on common cabbage.[z]

Insecticide	Rate (kg a.i./ha)	No. Cabbage Worm Larvae + Pupae per 20 Plants							Yield (t/ha)
		2-4-85	2-15-85	2-26-85	3-6-85	3-12-85	3-19-85	3-26-85	
1. CME-134 15SC	0.0375	5.75 b	10.00 b	4.50 bc	2.00 b	1.75 b	1.25 bc	1.50 b	77.97 a
2. CME-134 15SC	0.0750	6.00 b	6.50 b	4.00 bc	2.00 b	0.25 b	0.25 c	0.25 b	77.85 a
3. IKI-7899 5EC	0.050	4.25 b	9.25 b	3.50 bc	5.25 b	3.00 b	3.25 b	1.50 b	74.65 ab
4. DU-319722 10LQ	0.035	3.25 b	7.25 b	12.00 b	4.50 b	3.50 b	1.00 bc	1.75 b	64.68 bc
5. DU-319722 10LQ	0.070	5.00 b	9.00 b	4.25 bc	3.00 b	2.00 b	2.25 bc	3.00 b	70.25 abc
6. DU-415155 10LQ	0.035	5.75 b	4.75 b	6.25 bc	1.75 b	1.50 b	1.50 bc	1.75 b	61.83 cd
7. DU-415155 10LQ	0.070	3.75 b	9.50 b	2.75 c	4.25 b	1.50 b	2.25 bc	2.00 b	61.23 cd
8. Dimilin 25EC	0.140	1.50 b	3.00 b	5.25 bc	2.25 b	1.75 b	1.25 bc	0.50 b	52.70 de
9. Selecron 50EC	0.50	0.00 c	1.25 b	0.75 c	2.25 b	0.50 b	1.75 bc	3.50 b	66.29 bc
10. Check		28.50 a	80.75 a	66.50 a	44.00 a	18.50 a	10.25 a	11.25 a	48.75 e

[z]Cultivar: K-Y Cross; transplanting date: 12-27-84; insecticides applied: 1-8-85, 1-15, 1-22, 1-29, 2-5, 2-12, 2-22, 2-27, 3-6, 3-13, 3-20; harvest date: 3-27-85; plot size: 15 sq m. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

Table 11. Evaluation of insecticides for the control of diamondback moth on common cabbage.[z]

Insecticides	Rate (kg (a.i./ha)	No. Diamondback Moth Larvae + Pupae per 20 Plants							Yield (t/ha)
		2-4-85	2-15-85	2-26-85	3-6-85	3-12-85	3-19-85	3-26-85	
1. CME-134 15SC	0.0375	14.75 c	11.75 c	8.00 d	7.25 e	14.00 c	14.7 d	17.5c	77.97 a
2. CME-134 15SC	0.0750	11.25 c	11.75 c	5.75 d	5.50 e	11.75 c	8.7 d	6.5c	77.85 a
3. IKI-7899 5EC	0.050	26.50 c	22.25 c	42.75 d	44.25 e	42.25 c	32.0 d	24.7c	74.65 ab
4. DU-319722 10LQ	0.035	61.00 bc	89.25 c	104.75 bcd	214.75 d	232.50 c	161.. cd	188.2b	64.68 bc
5. DU-319722 10LQ	0.070	39.75 c	66.00 c	57.00 cd	158.25 de	156.75 c	101.2 d	179.0b	70.25 abc
6. DU-415155 10LQ	0.035	72.25 bc	99.50 c	164.00 bc	624.25 b	589.00 b	397.7 b	371.2a	61.83 cd
7. DU-415155 10LQ	0.070	118.00 b	137.50 c	181.50 b	462.75 c	520.00 b	421.0 b	402.2a	61.23 cd
8. Dimilin 25EC	0.140	189.50 a	268.25 b	384.25 a	1343.25 a	951.50 a	692.2 a	428.2a	52.70 de
9. Selecron 50EC	0.500	54.50 bc	72.00 c	108.00 bcd	689.50 b	629.25 b	624.2 a	452.5a	66.29 bc
10. Check		204.00 a	411.50 a	386.50 a	692.75 b	528.00 b	269.0 bc	153.0b	48.75 e

[z]Cultivar: K-Y Cross; transplanting date: 12-27-84; insecticides applied: 1-8-85, 1-15, 1-22, 1-29, 2-5, 2-12, 2-22, 2-27, 3-6, 3-13, 3-20; harvest date: 3-27-85; plot size: 15 sq m. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test.

Table 12. Screening of *B. thuringiensis* strains for the control of diamondback moth and cabbage worm on common cabbage[z]

Insecticides (Bt strains)	Rate (kg/ha)	No. of DBM or CW Larvae + Pupae per 10 Plants[y]										Yield (t/ha)
		3-7-85		3-14-85		3-21-85		3-27-85		4-3-85		
		DBM	CW	DBM	CW	DBM	CW	DBM	CW	DBM	CW	
1. H7 7,500 iuAK/mg FL	0.50	54 d	3.8 b	64 cd	4.0 b	129 cd	7.3 bc	148 bc	4.5 b	111 ab	4.3 b	58.8 ab
2. H7 "	1.00	40 d	2.3 b	51 cd	5.5 b	88 d	5.0 bc	89 c	2.0 b	71 ab	0.8 b	59.7 ab
3. H7 "	1.50	41 d	3.5 b	39 d	6.5 b	100 d	4.5 bc	87 c	4.5 b	66 b	2.3 b	57.7 abc
4. H3a3b 8,500 iuAI/mg FL	0.50	79 cd	4.3 b	78 cd	5.3 b	183 bc	3.0 c	165 bc	5.3 b	109 ab	3.8 b	51.3 bc
5. H3a3b "	1.00	48 d	4.8 b	49 cd	2.3 b	140 cd	4.5 bc	108 c	3.8 b	68 b	2.0 b	59.1 ab
6. H3a3b "	1.50	40 d	3.3 b	46 cd	4.5 b	96 d	6.3 bc	88 c	2.0 b	66 b	3.0 b	61.3 a
7. Bactospeine 16,000 iuAK/mg FL	0.25	112 bc	4.3 b	140 ab	6.3 b	236 ab	10.0 b	212 b	2.8 b	152 a	4.3 b	49.4 c
8. Bactospeine 16,000 iuAK/mg FL	0.50	121 b	4.3 b	99 bc	2.8 b	192 bc	3.8 bc	175 bc	5.3 b	126 ab	4.5 b	53.2 abc
9. Bactospeine 16,000 iuAK/mg FL	0.75	69 d	4.0 b	93 bc	4.8 b	186 bc	6.8 bc	163 bc	7.0 b	121 ab	5.8 b	53.9 abc
10. Control		250 a	29.3 a	178 a	28.0 a	269 a	29.8 a	332 a	42.5 a	124 ab	52.0 a	35.0 d

[z]Cultivar: K.Y. Cross; transplanting date: 1-6-85; insecticide applied: 1-15-85, 2-1, 2-8, 2-15, 2-22, 3-1, 3-8, 3-15, 3-22, 3-28; harvest date: 85/4/12. Plot size: 15 sq m. Data are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test. [y]DBM = diamondback moth; CW = cabbage worm.

Chinese Cabbage Pathology

Resistance of Chinese Cabbage Hybrids to Downy Mildew under Field Conditions

Introduction

Open-pollinated Chinese cabbage lines (77M(3)-27 and 77M(3)-35) known to be resistant to downy mildew have been tested in previous years. Components of resistance in these lines were exhibited in several forms. When measured nine days after inoculation, the resistant lines had fewer and smaller lesions. Regression of disease parameters (either square root of the number of infected leaves or arcsin square root of the percentage of area infected) over time showed that mean disease levels were lower for the resistant lines and that the rate of disease increase was also lower in these two resistant lines.

Many F1 hybrids resistant to downy mildew have also been developed by AVRDC. Their levels of resistance, however, were demonstrated solely in *in vitro* research. Hence, this study was conducted to confirm the resistance of these hybrids under field conditions.

Materials and Methods

Nine hybrids were tested with both of the resistant open-pollinated lines and one susceptible line as check varieties. Seeds were sown on 8 February and the seedlings transplanted to the field on 12 March in a randomized complete block design with four replicates. Each plot had 10 plants, and the replicates were separated from each other by a 3-m wide border of maize. On 27 March the plants were inoculated by spraying them until run-off with a suspension of *Peronospora parasitica* sporangia (1.1×10^4 sporangia/ml).

Seven days later, the number of lesions per plant and the mean lesion size for each plant were determined for all entries. In addition, the number of infected leaves per plant and the percent area infected per plant was recorded 14, 21, and 28 days after inoculation. The percent area affected was also recorded 35 days after inoculation for all plants, except for two lines that had already bolted.

The data of lesion size and number were subjected to an analysis of variance, and means were compared with an LSD. The regression analysis was used for the data on area infected and number of infected leaves (dependent variables) which had to be transformed (with the use of square root and arcsin square root, respectively) to stabilize the variance. The independent variable was days after inoculation.

Results and Discussion

When disease was measured (from either lesion size or number) seven days after inoculation, differences among the different entries was clearly apparent (Table 1). All material under consideration had smaller and fewer lesions than the susceptible check, B14, though not all differences were statistically significant. Examination of the residuals from the ANOVA indicated that a transformation of these data was not necessary.

A sequence of regression models indicated that the rate of disease increase (from either number of leaves or area infected appropriately transformed as measure of disease) varied from entry to entry.

When percent area infected was used as the disease parameter, the highest rate of disease increase was in the susceptible check. Counting the number of infected leaves did not yield the same results, however, and several entries yielded regression lines essentially the same as those of the susceptible check (Table 2).

Table 1. Lesion size and number on Chinese cabbage lines measured seven days after inoculation.

Line	Lesion size	Lesion number
Hybrid 58	.17	30.95
Hybrid 58 R	.13	32.93
Hybrid 59	.13	22.98
Hybrid 62	.11	4.10
Hybrid 62 R	.13	5.68
Hybrid 82-46	.14	8.13
Hybrid 156	.17	23.60
Hybrid 157	.19	20.98
77M(3)-27	.12	10.98
77M(3)-35	.11	8.70
B 14	.21	47.85
95% LSD	.0009	25.05
99% LSD	.0012	33.68

Table 2. Rates of disease increase in Chinese cabbage lines computed from two disease parameters.

Line	Arcsin (% area infected) intercept	Arcsin (% area infected) slope	Sqrt (# leaves infected) intercept	Sqrt (# leaves infected) slope
Hybrid 58	.0253	.0123	1.1140	.0942
Hybrid 58 R	.0329	.0118	1.0140	.0985
Hybrid 59	-.0732	.0137	.7602	.1017
Hybrid 62	-.1382	.0154	.4331	.1115
Hybrid 62 R	-.1408	.0161	.5930	.1084
Hybrid 82-46	-.0269	.0107	1.5340	.0514
Hybrid 82-46 R	-.0552	.0115	1.3630	.0564
Hybrid 156	.0024	.0145	.9393	.0963
Hybrid 157	-.0846	.0192	.9727	.0977
77M(3)-27	.0442	.0095	.6940	.0916
77M(3)-35	.0500	.0104	.6345	.0929
B 14	.1040	.0228	1.2970	.0965

The open-pollinated lines 77M(3)-27 and 77M(3)-35 showed high levels of resistance relative to the susceptible check, B 14, in this experiment. The F1 hybrids also displayed various levels of resistance, but none of them were completely immune to downy mildew. This would be expected since the hybrids were developed, in part, from these open-pollinated lines; and no sources of total immunity to downy mildew have been identified within our Chinese cabbage germplasm.

When disease was measured one week after a controlled inoculation, the resistance appeared most dramatically as a reduction in the number of lesions. The variance with this parameter was so large, however, that not all differences were significant. If disease was measured with lesion size, the differences were much smaller, but they were all significant.

All entries displayed resistance relative to the susceptible check in a lower overall mean and a reduced rate of disease increase when percent area infected was used as the disease parameter. The differences were not as obvious when number of infected leaves was used. Although the number of infected leaves is a more objective method of quantifying disease, it is inherently less accurate, since it cannot compensate for the relative diseased area of each leaf.

Conclusion

Hybrid Chinese cabbage lines developed by AVRDC have partial resistance to downy mildew under field conditions. As in the open pollinated lines, 77M(3) 27 and 77M(3) 35, these hybrids lines displayed resistance in the form of reduced lesion size and lesion number and a reduced rate of disease increase (with either number of infected leaves or percent area infected as the disease parameter) when compared to the susceptible check, B 14.

Levels of resistance varied in the hybrids, though some had levels approaching that of the open pollinated lines. Lesion size appeared to be the best disease parameter when only a single disease assessment was used, and percent area infected was the best measure when the resistance was being compared on an epidemiological basis.

In Vitro Studies on Downy Mildew Resistance in Chinese Cabbage

Introduction

Last year's studies measured downy mildew resistance *in vitro* on young cotyledons of 77M(3)-27, 77M(3) 35, ASVEG 1 (Hybrid 62), and Hybrids 58 and 59. The resistance of these materials has also been confirmed in field screenings this year which included four additional hybrids that had not yet been tested *in vitro*. This study report on the results from *in vitro* testing of 82-46, 82-46 R, 82-156, and 82-157, the new hybrids, in addition to their parental lines.

Materials and Methods

Peronospora parasitica was isolated from the field and maintained in an illuminated 14°C incubator by weekly transfer of sporangial suspensions to detached cotyledons of Chinese cabbage line, B 14. Ten- to twelve day old cotyledons were used as a substrate for growing the fungus which sporulated about one week after inoculation. For routine maintenance, sporangial concentrations were in the range of 10^4 to 10^5 sporangia/ml.

Lines were tested by sowing seeds and removing the cotyledons of 12 day old plants. These cotyledons were placed on moist filter paper in 5 cm petri dishes with the abaxial surface up. A total of five dishes were prepared for each cultivar or line in this manner. Cotyledons were inoculated with a suspension of sporangia (1.0×10^5 for 82-46 and 3.0×10^5 for 82-156 and 82-157).

Four or five days after inoculation, all five cotyledons were removed from one dish of each cultivar, placed in 5 ml of water, and shaken with a Vortex Genie mixer. The concentration of the resulting spore suspension was determined with a hemacytometer. Data were analyzed by multiple regression and a model sequence to see if slopes of different lines were different. The dependent variable (spore number) was transformed by taking its square root, the independent variable was days after inoculation.

Results and Discussion

Since spore number would a *priori* have a Poisson distribution, and analyses from both last year and this year indicated that the data transformed with a square root had a more uniform variance, only the results of the transformed data were presented this year. Plots of both raw and transformed data are, however, presented in Figs. 1 and 2.

The rates of spore production were not the same, as indicated by the large F values in the analysis of variance. In the experiment with 82-46, slopes ranged from -.4808 for 77M(3) 38-11-2-21 to 1.2403 for B 14, and in the one with 82-156 and 82-157, from -.2384 for PI 1 to 1.00287 for B 14 (Tables 3 and 4).

In both tests, the rate of spore production and the overall mean were higher for the susceptible check than for the material being tested (Tables 5 and 6). Thus, all four hybrids displayed resistance in the *in vitro* test. There were no differences between 82-156 and 82-157, and between 82-46 and 82-46R. The regression lines from the parental material were different from each other and showed the same pattern as those of last year. When the sum of squares were compared for various differences

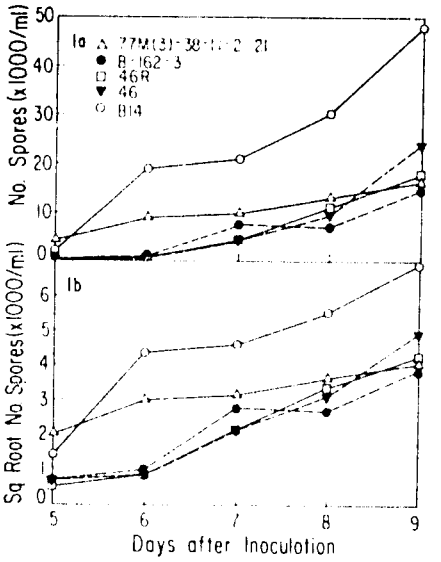


Fig. 1.
Sporulation of five cultivars five to nine days after inoculation. Spore number per milliliter of five cotyledons was taken from the average of four replications in 5 ml of water. Raw data is presented in Fig. 1a. Data transformed with square root is presented in Fig. 1b.

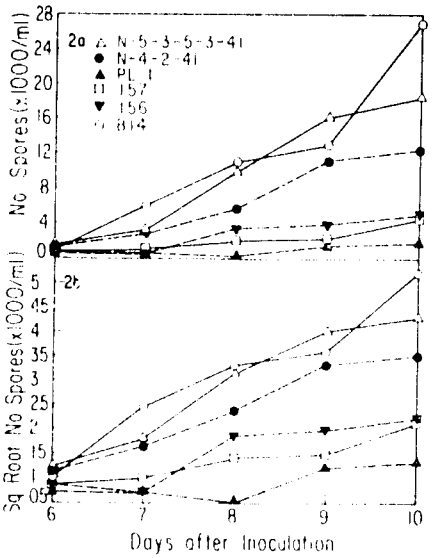


Fig. 2.
Sporulation of six cultivars six to ten days after inoculation. Spore number per milliliter of five cotyledons was taken from the average of four replications in 5 ml of water. Raw data is presented in Fig. 2a. Data transformed with square root is presented in Fig. 2b.

Table 3. Regression coefficients for 82-46 and 82-46R[z].

Line	Intercept (value)	Slope (value)
82-46	-5.3969	1.0904
82-46 R	-4.9987	1.0112
77M(3)-38-11-2-21	.2598	.4808
B 162-3	3.7425	.8356
B 14	4.1711	1.2403

[z]Dependent variable is square root of spore number

Table 4. Regression coefficients for 82-156 and 82-157[z].

Line	Intercept (value)	Slope (value)
82-156	-2.1217	.43926
82-157	-1.4789	.34287
PL 1	1.1092	.23284
N-4-2-41	2.8056	.64895
N-5-3-5-3-41	3.8122	.83321
B 14	-5.0718	1.00787

[z]Dependent variable is square root of spore number

between a reduced one line model and a complete five or six line model, most variations could be accounted for by differences between the susceptible and resistant materials, or between the various inbred parents.

There were some differences, however, from the results of last year. In this set of tests, the regression lines for the hybrids were significantly different from those of the parental average, indicating

Table 5. ANOVA comparing hybrids 82-46, 82-46R, parents, and B 14.[z]

Source	DF	SS	MS	F
Intercept	1	735.27	735.27	
Day	1	172.25	172.25	105.0580
Residual	93	152.48	1.639570	
Additional SS for adding the following variables				
Susceptible B 14	2	78.45	39.225	48.21660
Residual	91	74.03	.8135165	
F1's and Parents	2	8.68	4.34	5.910635
Residual	89	65.35	.7342697	
Separating 77M(3)..... ..... B 162	2	11.23	5.615	9.026330
Residual	87	54.12	.6220690	
Separating 82-46 from 82-46 R	2	.37	.185	.2925581
Residual	85	53.75	.6323529	

[z]Dependent variable is square root of spore number

Table 6. ANOVA comparing hybrids 156, 157, parents, and B 14.[z]

Source	DF	SS	MS	F
Intercept	1	451.963	451.963	
Day	1	81.901	81.901	66.46391
Residual	118	145.407	1.232263	
Additional SS for adding the following variables				
Susceptible B 14	2	35.137	17.5685	18.48142
Residual	116	110.27	.9506034	
F1's and Parents	2	12.317	6.1585	7.167407
Residual	114	97.953	.8592368	
Separating N4/N5 & PL 1	2	53.323	26.6615	66.90764
Residual	112	44.63	.3984821	
Separating N4 from N5	2	2.865	1.4325	3.772896
Residual	110	41.765	.3796818	
Separating 156 from 157	2	.351	.1755	.4576713
Residual	108	41.414	.3834630	

[z]Dependent variable is square root of spore number

possible nonadditive results. Further examination of the regression lines showed that one inbred line, PL 1, showed a very low rate of spore production. This line, however, is derived from the susceptible check, B 14, and should not display any resistance.

Physical examination of the inbreds revealed that they had much smaller cotyledons than the hybrids or open-pollinated lines, and this finding should be taken into account as a covariate, in case it is adversely affecting total spore production. Unfortunately, no size data was available for this particular experiment, so that it was not possible to include this. Other factors may influence the rate of spore production; and with the inbreds, *in vitro* testing may not be a satisfactory method of estimating downy mildew resistance.

Although rate of spore production may be a useful means of estimating downy mildew resistance in young, vigorous materials, its use on inbreds (which lack the vigor of the hybrids) will need further

refinement. Further work on quantifying partial resistance of parental stocks under field conditions would also provide useful information about the genetics of resistance.

Conclusion

Studies from last year confirmed the ability to measure downy mildew resistance *in vitro* on young cotyledons. This year additional lines were tested using the *in vitro* method. All of the hybrids displayed a level of resistance between the parentals with an indication of nonadditive gene action. The rate of spore production is a useful means of estimating downy mildew resistance in young, vigorous material; however, its use on inbreds, which lack the vigor of hybrids, will need further refinement.

Screening of Germplasm for Resistance to TuMV Strain C4

Introduction

Previous screenings have indicated that resistance to TuMV strains 1, 2, and 3 (but not to C4 and C5) is readily available in AVRDC's germplasm collection. Therefore, our accessions are initially screened only for C4 and C5 to detect genes for resistance to these two strains.

Materials and Methods

Sixteen *Brassica* sp. accessions (B 11, 40, 111, 129, 141, 161, 170, 180, 189, 289, 443, 444, 448, 613, 778, and 779) which are or will be utilized in our ongoing breeding program were screened for resistance to TuMV C4 by the method described in the 1984 annual report.*

Results and Discussion

Only one accession, B 779, was found resistant to C4; it produced only one infected plant among 31 that were inoculated. This line will be rescreened with TuMV C4 to verify resistance. All lines will also be screened for resistance to TuMV C5.

Conclusion

B 779 was the only accession resistant to C4.

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*AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

Chinese Cabbage Physiology

Water Needs of Chinese Cabbage at High Temperature for Head Formation

Introduction

High temperature prevents the head formation of most heat-sensitive Chinese cabbages. Previous studies demonstrated that the head formation of heat-tolerant Chinese cabbage at high temperature was controlled by low leaf osmotic potential, which is mainly attributed to high amount of cell sap ions. Heat-tolerant Chinese cabbage also possesses thick leaves with less stomatal number, and an extensive root system. These characteristics facilitate water uptake and reduce transpiration, thereby enhancing leaf erection during the initiation of the heading process.

Last year, we reported that heat tolerant Hybrid No. 62 produced bigger heads, had greater dry weight, and utilized water more efficiently than heat sensitive B-33 under high temperature conditions. The purpose of this study was to determine water usage of Chinese cabbage plants throughout the growing period under high temperature conditions.

Materials and Methods

Seedlings of B 6, B 33, B 40, Hybrid No.58, and ASVEG 1 (Hybrid No.62) were first prepared in small plastic pots with a sand and soil mixture (1:1). Seedlings, 19 days after sowing, were transplanted to wooden boxes (25 x 25 x 30 cm) filled with a sand and soil mixture but underlaid with a 23 cm wide PVF sheet each. PVF sheets served as water carriers and extended through the bottom side-slit of wooden boxes to outside water containers. The sheets between boxes and water containers were covered with a dark plastic film to prevent direct evaporation and algal growth.

The completely dried culture medium was first fertilized with 3.2 g of N, 1.8 g of P_2O_5, and 2.6 g of K_2O per box before being poured into wooden boxes at 21 kg/box. The culture medium in the box was first equilibrated with water from the water container through PVF sheets for two weeks before weekly water uptake by the box was measured. Seedlings were later transplanted. No top irrigation was given throughout the experiment, the PVF sheets served as the sole water-carrier from the water container.

The experiment was conducted in the greenhouse with mean maximum and minimum temperatures of 32° and 23°C, respectively, during 50 days of growing in the box. There were three replicates, each replicate with three wooden boxes at one plant per box. Water taken up by each wooden box through the PVF sheet was measured from the water loss in the water container.

To separate the amount of moisture loss through the soil surface as opposed to that being lost from the plant, three wooden boxes without Chinese cabbage plants were maintained and handled similarly as the boxes with plants. The water used by the plants was calculated from the water loss difference between the boxes with plants and the control boxes.

Head weight, plant fresh and dry weights, leaf area of nonheaded leaves, and the water left in the wooden boxes were measured at harvest time. Water used, retained, and transpired was calculated and subjected to analysis of variance.

Results and Discussion

There were no head formation and head yield for B6 and B33, whereas B40 produced a small head. The average head weight for Hybrid Nos. 58 and 62 was above 500 g/head (Table 1). Results confirm that both hybrids were heat tolerant under present experimental temperature conditions. They also tended to have higher fresh weights than other entries. However, in terms of total dry weight no difference was observed between heat-tolerant and heat sensitive Chinese cabbages. The results suggest that head formation of Chinese cabbage at high temperature relies on the water balance of the plants rather than on their photosynthetic source.

Most of the water utilized by the plant was lost through transpiration; less than 5% of it remained in the plant (Table 2). The calculated water retention of the plant tended to increase in heat-tolerant Hybrid Nos. 58 and 62 both on the weight and percentage bases during the whole growing period. High water retention and low transpiration in these hybrids may have contributed to head formation at high temperature.

Table 1. Plant growth of Chinese cabbage with a water supply provided by PVF sheets.[z]

Entry	Fresh Weight (kg/plant)	Dry Weight (g/plant)[y]	Leaf Area (m^2/plant)	Head Weight (g/head)
B 6	1.18 b	80.86 ns	1.26 a	0 b
B 33	1.17 b	85.67	1.11 a	0 b
B 40	1.19 b	82.81	1.08 a	50 b
$F_1$58	1.39 ab	82.63	0.74 b	592 a
$F_1$62	1.42 a	81.14	0.75 b	623 a

[z]Plants were sown, transplanted, and harvested on 17 July, 5 Aug., and 26 Sept., 1985, respectively. Mean separation within columns by Duncan's multiple range test, 5% level.
[y]ns = not significant.

Table 2. Calculated water usage by Chinese cabbage plants.[z]

Entry	Water Content (kg/plant)	Water Content (%)	Water Usage (l/plant)	Water Retained (%)	DMPE[y] (ml water/g)
B 6	1.10 b	93.1 b	26.8	4.13 bc	331
B 33	1.09 b	92.7 b	29.9	3.65 c	351
B 40	1.11 b	93.1 b	29.8	3.77 bc	360
$F_1$58	1.31 a	94.1 a	30.8	4.34 ab	373
$F_1$62	1.34 a	94.3 a	27.4	4.92 a	336

[z]Mean separation within columns by Duncan's multiple range test, 5% level. [y]Dry matter production efficiency.

The results on actual amount used at specific growth stages revealed different perspectives of water usage (Fig. 1). Hybrid Nos. 58 and 62 at three to four weeks after transplanting utilized more water than heat sensitive Chinese cabbages. This seems to be in accordance with previous findings that heat-tolerant Chinese cabbage had better root development which facilitates water uptake, especially at the leaf erection and head posture stages. In both stages, much water is required to maintain leaf turgidity. In the same figure, heat sensitive Chinese cabbage used more water at a late stage, which could be the cause of continued transpiration in more nonheading leaves.

Heat tolerant entries contained more K in the petiole sap and more Mg in the root sap than other entries. Heat sensitive entries, however, contained more K in the stem sap (Table 3). In a separate experiment, it was also demonstrated that xylem sap of heat-tolerant Chinese cabbage contained more K (Table 4). Since K is usually considered as an osmoregulant, a high K in the petiole of Chinese cabbage may be involved in the process of leaf erection and head posture.

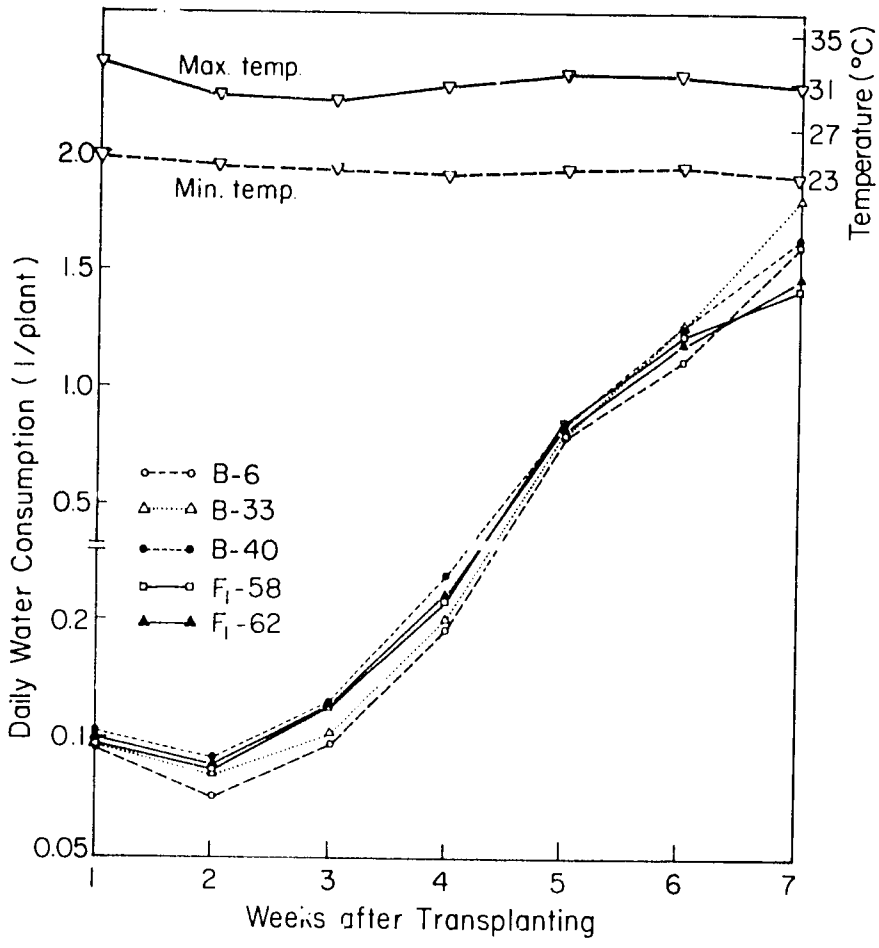

Fig. 1. Water consumption pattern of Chinese cabbage.

Table 3. Mineral contents (μg/ml) in the cell sap of various plant parts of Chinese cabbage.[z]

Mineral	Entry	Petiole	Stem	Base of Root
K	B 6	1338 b	2697 a	1096 b
	B 33	1218 b	2388 ab	2172 a
	B 40	1513 ab	2199 ab	1450 b
	$F_1$58	1683 ab	1903 b	2122 a
	$F_1$62	1727 a	1769 b	2376 a
Mg	B 6	129 b	218 a	208 c
	B 33	159 ab	148 b	238 bc
	B 40	174 a	211 a	300 ab
	$F_1$58	152 ab	119 b	339 a
	$F_1$62	143 b	172 ab	314 a

[z]Cell sap was collected by freezing and thawing of various plant parts, and centrifuged at 1000 rpm for 10 min. Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Potassium content in xylem sap of four Chinese cabbage entries cultivated in wooden boxes.[z]

Stage[y]	Entry	K µg/10 min	Stage[y]	Entry	K µg/10 min[x]
10 DAT	B 6	43.4	30 DAT	B 6	55.3 b
	B 40	40.8		B 40	82.6 ab
	$F_1$58	45.7		$F_1$58	102.8 a
	$F_1$62	40.7		$F_1$62	80.2 ab
20 DAT	B 6	53.5	40 DAT	B 6	64.3 c
	B 40	50.2		B 40	89.1 bc
	$F_1$58	66.4		$F_1$58	167.0 a
	$F_1$62	52.8		$F_1$62	140.3 ab

[z]Xylem sap was collected by vacuum for 10 min. [y]DAT Days after transplanting. [x]Mean separation within columns by Duncan's multiple range test, 5% level.

Conclusion

Heat-tolerant Hybrid Nos. 58 and 62 which produced heads at high temperature utilized more water at stages where leaf erection and head posture occurred. This may be necessary in order to maintain turgidity of the leaves during these periods. On the other hand, heat sensitive Chinese cabbage used more water than heat-tolerant ones at the later stage, which probably accounted for more transpiration occurring in the nonheaded leaf area of this cabbage. Heat-tolerant Chinese cabbage also contained more potassium in the cell sap of the leaf petiole; this may be related to water retention in the petiole for the leaf erection process.

Sweet Potato Breeding

Hybridization Program

The crossing program produces the basic materials for the AVRDC breeding projects. Since sweet potato is a vegetatively propagated crop and all the multi-stage evaluations afterwards are aimed to identify only elite genotypes without any more genetic recombination, the crossing program is the only stage where desirable genotypes can be created or secured. Emphasis is on the use of the deliberately chosen parental clones according to specific breeding objectives and to produce seeds in amounts large enough to include the best, but infrequent, genotypes in this highly heterozygous and polyploid crop.

In the 1984-85 crossing project, the priority was on the improvement of dry matter yield and eating quality, and resistance to stem borer and scab disease. As shown in Table 1, more seeds were produced by the natural way of pollination, such as by open pairs and polycrosses, than by hand pollination. These seeds provided materials for the botanical seed trials in 1985.

Table 1. Objectives and number of seeds produced in the sweet potato hybridization programs of 1984-85.

Crossing Type/ Objective	No. of Combination	No. of Seeds Harvested
Hand-crossing	34	22,499
To raise dry matter yield and improve adaptability and scab resistance	(13)	(8,723)
To improve eating quality, plant type, and dry matter	(21)	(13,776)
Open-paired	2	246,784
To incorporate scab resistance	(1)	(58,264)
To raise dry matter yield of elite lines	(1)	(188,520)
Polycross		227,832
To incorporate stem borer resistance		(11,598)
To increase protein content		(69,695)
To obtain improved plant type		(146,539)
Open pollination		288,975
To raise dry matter yield and improve adaptability and scab resistance		(69,914)
To improve eating quality, plant type, and dry matter		(219,061)
Total		786,090

Botanical Seed Trials

Introduction

As the first step in identifying the elite clones, botanical seed trials (BST) deal with a very large number of genotypes. In 1985, a total of 56,626 seeds from different crossing programs was included; and selection was done mainly on the simply inherited traits.

Materials and Methods

Plant materials were divided into two different batches. The first batch, comprising 34,367 seeds produced from different crossing blocks by natural pollination, was sown on 16 April. The second batch with 22,259 seeds produced by hand pollination was sown on 17 May. Spacing was 15x15 cm on 1-m-wide beds. Harvest and evaluations for selection was done from July 25 to 29 and from September 2 to 4 for the first and second batches, respectively.

Seedlings without storage roots and those with purple flesh color were discarded first. Storage roots of all other entries were checked on specific gravity by brine solutions. The entries whose specific gravity was above 1.05 or 1.06 were finally selected, depending upon the population.

Results and Discussion

From the first and second BST batches, 2,147 and 279 entries were selected, respectively, for storage roots high in specific gravity without any purple flesh pigmentation. The selection rate of the first batch was 6.25% and that of the second was 1.25%, making a pooled rate of 4.28%. All these selections were entered in the next evaluation step – observational yield trials.

Conclusion

Based on the ability to form storage root, on freedom from undesirable flesh pigmentation, and on high specific gravity of the root, 2,426 entries were selected for the observational yield trials.

Observational Yield Trials

Introduction

The observational yield trial (OYT) is the first clonal evaluation step; therefore, a large number of entries are tested in a very limited plot size without replications. Selections were done on the basis of dry matter content, general appearance, and uniformity.

Materials and Methods

A total of 7,035 clones were included in three OYTs. OYT 1 with 4,280 clones was planted on 24 May to be harvested on 24 October. OYT 2 with 1,780 entries was transplanted on 4 June and harvested in early October. OYT 3 with 975 entries from a protein-content-improvement program was planted 16 July and harvested three months later. Five cuttings per entry were planted with spacings of 1 m between two adjacent rows and 0.25 m between hills, without replications.

After discarding purple fleshed, very low yielding, poor-shaped clones, dry matter content was estimated first by the organoleptic method and next by brine solutions adjusted to 1.02 to 1.05 of specific gravity. Preselected clones in this way were measured for root weight and then for actual dry matter, protein, and other chemical components by our biochemists.

Results and Discussion

Table 2 shows the selection rates from three different OYTs. More than 93% of the total entries were discarded in the field evaluations including specific gravity screenings. Finally, only 1.01% or

71 clones out of 7,035 initial entries were selected for the preliminary yield trials with large, replicated plots. Selections from OYT 1 and OYT 2 have already been entered in a PYT.

Table 2. Selections from observational yield trials.

		OYT 1	OYT 2	OYT 3	Pooled
No. of entries	(A)	4,280	1,780	975	7,035
Preselection	(B)	507	50	56	613
Final selection	(C)	46	17	8	71
Selection rate	C/A%	1.07	0.96	0.82	1.01

Table 3. Range and mean (in parenthesis) of selected clones from OYT in several traits.

	OYT 1		OYT 2		OYT 3	
N	46		17		8	
Root wt (g plant)[z]	1,600-5,000	(2,310)	1900-7380	(3.06)	126-602	(310)
Dry matter content (%)	30.0-37.7	(33.1)	30.3-42.6	(34.5)	30.2-31.7	(30.8)
Protein content (%)[y]	3.04-4.14	(3.52)	–	–	2.37-4.95	(4.18)

[z]Different growing periods, 5 months in OYT (observational yield trial) 1, 4 months in OYT 2, and 3 months in OYT 3. [y]Dry matter basis.

Root weight, dry matter content, and protein content of the selected entries are shown in Table 3. Protein content was not always possible to measure, because of the limited amount of root samples. The content in some OYT 3 entries, from a crossing block for high protein content, was as high as 6.4%. Entries with dry matter content below 30% were all discarded. Some selections had 37 to 42% dry matter content.

Conclusion

Selections were made primarily on the basis of flesh color, appearance, uniformity, and specific gravity of the roots and secondarily on dry matter content and other recorded characters. Seventy-one clones were selected to be entered in the preliminary yield trials.

Rapid Screening Techniques

Introduction

The success of any sweet potato breeding program depends upon the efficiency in identifying desirable clones from seedlings or early vegetative generations. The evaluation efficiency is controlled largely by the assessment techniques and consistency of the traits in different stages of the trials. In 1985, the consistency of plants to form storage roots between the seedling and vegetative clonal stage was studied, in addition to the rapid assessment techniques for dry matter and protein contents in cooperation with the Chemistry Department. Simple observations on flesh and skin color and yield were also made.

Materials and Methods

A total of 975 BST entries were carried over to OYT 3 regardless of their ability to form storage roots in the former trial stage. To establish OYT, five cuttings were planted for each entry. Spacing

was 1 m between two adjacent rows and 0.25 m between hills. In contrast, BST was sown with a spacing of 15 x 15 cm on 1-m-wide beds. Observations on root formation, color of root skin and flesh, and other traits were made three months after sowing or planting. At harvest the specific gravity (SG) of roots from all entries with storage roots were scored with three different levels of saline water. Scores of 2, 3, 4, and 5 were given for SG < 1.00, 1.00 ≤ SG < 1.02, 1.02 ≤ SG < 1.05, and SG ≥ 1.05, respectively.

Ninety-two randomly chosen entries were measured for actual dry matter and protein contents. Protein measurement of BST entries was done by the color rating method using the tetrabromophenol blue indicator paper (see 1983 Progress Report[5]). Some additional correlation analyses were also done with available data from other experiments on the consistency of dry matter content and yield in different clonal evaluation stages.

Results and Discussion

About 90% of the clones which formed storage roots in the botanical seed generation also produced roots in the first clonal generation, whereas only 50% formed storage roots from the group which did not root in the BST. Thus, before moving on to OYT it is recommended to discard all seedlings which failed to form roots in the BST.

Quite a high percentage of entries showed apparent color change in skin (22%) and flesh (31%) between BST and OYT. Such changes are not readily explained. However, it is still recommended to discard all the roots with undesirable skin and/or flesh color in the BST as a mass screening method.

A highly significant positive correlation was obtained between actual dry matter content and specific gravity in both trial stages. The correlation between the two different generations was also highly significant on both features (Table 4). The positive effects of selecting for high specific gravity are also evident in Table 5. Furthermore, a good correlation between different generations and growing environment was also observed between an OYT and two PYTs in different seasons (Table 6).

Table 4. Correlation coefficients between dry matter content and specific gravity scores of BST and OYT.[z]

		DM		SG score	
		BST	OYT	BST	OYT
DM	BST		.599**	.662**	.335**
	OYT		–	.472**	.622**
SG Score	BST			–	.345**
	OYT				–

[z]DM = dry matter content; SG = specific gravity; BST = botanical seed trial; OYT = observational yield trial; specific gravity scores, below 1.00 = 2, 1.00 to 1.02 = 3, 1.02 to 1.05 = 4, and above 1.05 = 5; ** = significant at the 1% probability level (df = 90).

Table 5. Percentage of clones in the observational yield trial belonging to different specific gravity scores as affected by the score in the botanical seed trial.[z]

SG in BST	SG Score in OYT							
	2		3		4		5	
2	33	(25.6)	49	(38.0)	41	(31.8)	6	(4.6)
3	14	(9.4)	47	(31.5)	76	(51.0)	12	(8.1)
4	3	(15.2)	17	(12.7)	78	(58.2)	36	(26.9)
5	1	(2.7)	2	(5.4)	16	(43.2)	18	(48.7)
Total	51	(11.4)	115	(25.6)	211	(47.0)	72	(16.2)

[z]Specific gravity score is as shown in Table 8; X^2 = 121.41, P = .001. OYT = observational yield trial.

[5] AVRDC. 1985. 1983 Progress Report. Shanhua, Tainan, Taiwan.

Table 6. Comparative correlation coefficients for dry matter content and fresh weight yield between OYT and two PYTs.

Trial[z]	Correlation Coefficient[y]	
	dm content	fw yield
OYT (F) - PYT (F)	.699**	.251
OYT (F) - PYT (S)	.536**	.047
PYT (F) - PYT (S)	.575**	.072

[z]F = fall, S = summer, OYT = observational yield trial, PYT = preliminary yield trial. [y]** = significant at the 1% probability level (n = 227).

A certain degree of discrepancy between specific gravity and actual dry matter might arise from sponge-like, loose textured or weevil-damaged hollow roots, which all decrease specific gravity but do not affect the actual dry matter content. In these cases, the SG method may have an incidental advantage in discarding such undesirable seedlings.

Although the color rating by the tetrabromophenol blue indicator paper was previously identified as a reliable rapid detection method for protein content in sweet potato by AVRDC biochemists, its application for mass screening in the BST is not recommended. The correlation coefficient between color rating in the BST and actual protein content in the OYT was 0.002 (df = 90 in the same samples used for the dry matter analyses shown above. Such inconsistency or low correlation over different stages is attributed to the nature of the trait which is significantly affected by environmental factors. A similar trend was found in yield, too (Table 6).

Conclusion

Selection for dry matter content by specific gravity in BST and OYT proved reliable with excellent consistency and a highly significant correlation between specific gravity and actual dry matter content. Selection for root skin and flesh color, as well as for ability to form storage root in BST, was also recommendable. Yield and protein content, however, showed poor consistency over different vegetative generations.

Selecting Promising Clones in the Preliminary Yield Trials

Introduction

Thousands of new genotypes undergo rigorous selection every year for various morphological, chemical, and general characters considered important in the improvement program. By the time these genotypes reach the preliminary yield testing stage, more than 90% of the original seedling population will have been already discarded. Thereafter, more exhaustive tests for complex characters, like yield, are undertaken starting first at the preliminary yield trial.

Such repeated trials enable the breeders to select clones with good adaptability to a range of environments. As sweet potato is commonly grown in the tropics under both favorable and marginal conditions, the selection of such clones is considered essential. In 1984-85, a number of preliminary yield trials were conducted to select the best genotypes for inclusion in the next stage of testing, the advanced yield trial.

Materials and Methods

A total of 352 new selections derived from the 1983 fall to 1984 spring observational trials were planted, along with check clones, in a series of preliminary trials (PYT). Because of the large number of entries, the total was divided into 26 PYT groups. The common check cultivar for all groups was TN 66, a stable, high-yielding local variety with good general acceptability. An adequately tested

breeding line with good performance, CN 1108-13, also appeared as check in 20 of 26 PYT groups. In other trials other check lines were used, such as CN 1232-9 and CN 1028-15.

Each group was planted in a randomized complete block design with two or three replications, depending upon availability of planting materials. A unit plot consisted of a single row, 5 m long, with rows spaced 1 m apart and plants within the row, 25 cm apart. All groups were planted on 28 October 1984 and harvested on 28 February 1985. In order to select clones with wide adaptability, the data from these trials were compared with those of the previous 1984 summer PYT involving the same materials.

Results and Discussion

A total of 26 clones were selected from the 26 PYT groups. The selection rate among these materials was about 7%. The best (or elite) selections are listed in Table 7. Compared to TN 66, which showed a relatively high stable yield in both the 1984 summer and fall PYTs, a number of new selections appear to be comparable if not better. In terms of average yield in both seasons, the best new clone was CN 1542-8. This clone tended to yield better in the fall than in the summer, as most clones usually do.

For fairly stable yields in both seasons, clones CN 1517-139 and CN 1434-2 appear to be the best. With the exception of CN 1448-37, the new selections also showed stable, higher dry matter content than the check cultivars. The best cultivar with consistently high dry matter content was CN 1489-22. On this character the most stable, however, were CN 1434-2, CN 1510-25, and CN 1517-139, all with consistently high marketable yields in both seasons.

Among the elite selections, none had the deep orange flesh considered more nutritious (high vitamin A) for human consumption. However, a few of them were identified among the secondary selections (not listed in Table 7). Some of the elite selections, like those with a predominantly yellow flesh having an orange tinge (e.g., Y301 or Y401 flesh score), may qualify as staple/dessert types of clones.

All selected clones from the above PYTs were entered in the 1985 advanced yield trials to further select the most outstanding clones for eventual entry into multilocation trials and distribution to international cooperators.

Conclusion

Of the 352 selections, 26 were further selected and subsequently entered in the 1985 advanced yield trials. In general, the best (or elite) selections had stable high yields in both the summer and fall season PYTs and were also characterized by consistently high dry matter content and yield relative to the check cultivars and breeding lines.

Stability Performance of High-Starch Clones

Introduction

Four advanced breeding lines were identified to have good starch yield potential in previous evaluation trials. In order to determine the stability performance of these clones, a series of advanced trials were conducted during the 1984-85 summer and fall seasons.

Materials and Methods

A total of eight entries was used in this experiment. This included four AVRDC clones compared with four local cultivars as checks. The first summer trial was planted on 28 June and harvested on 28 November 1984. The second summer trial was planted on 3 July and harvested on 3 December 1984. The fall trial on the other hand was planted on 7 December 1984 and harvested on 4 July 1985.

Each trial used a randomized complete block design with six replications. Unit plots consisted of two 10-m-long rows with rows spaced 1 m apart and plants within the row, 25 cm apart. Yield and other horticultural characters were recorded. The chemists were provided with samples of each

entry for appropriate chemical analyses.

Combined statistical analysis of data for marketable yield was done to enable the identification of high-yielding, stable clones.

Table 7. Yield and other characteristics of elite sweet potato selections derived from preliminary trials(Group 1-26) of 358 clones, AVRDC 1984-85.

Clone	Source Group	Marketable Yield (t/ha)			Dry Matter (%)			Dry Matter Yield (t/ha)			Root Characters[z]		
		84 Su	84 F	mean	84 Su	84 F	mean	84 Su	84 F	mean	unif	skin color	flesh color
CN 1542-8	20	28.8	45.2	37.0	34.7	33.4	34.1	4.8	15.1	10.0	F4	R7	Y2
CN 1517-139	21	32.1	32.6	32.3	36.3	32.6	34.4	11.7	10.6	11.2	G4	R2	Y3
CN 1448-49	18	21.1	43.2	32.1	34.0	32.9	33.4	7.3	14.2	10.8	F4	R4	Y4O1
CN 1510-25	21	29.7	33.8	31.7	32.4	33.4	32.9	9.7	11.3	10.5	F4	Y4R3	Y2
CN 1434-2	13	32.0	30.6	31.3	32.8	34.3	33.6	10.5	10.5	10.5	F4	Y5	Y4O1
CN 1448-37	18	23.9	38.6	31.2	28.9	28.5	28.7	7.0	11.0	9.0	F4	R3	Y3O1
CN 1508-84	15	19.4	42.6	31.0	30.9	30.4	30.6	6.0	13.0	9.5	F4	O3	Y2
CN 1489-22	14	20.7	39.6	30.1	39.4	38.8	39.1	8.1	15.4	11.8	F4	Y1	Y1
CN 1108-13		16.0	34.6	25.3	27.0	28.0[y]	27.5	4.3	9.7[y]	7.0	G6	O3Y3	O3Y3
CN 1232-9		11.1	30.8	21.0	22.4	29.2[x]	28.3	3.0	8.0[x]	5.5	G6	Y1	Y1
TN 66		20.6	34.3	27.4	22.3	29.4[w]	28.4	5.4	10.4[w]	7.9	G6	O3R1	O3Y3

[z]F = fair, G = good (unif.); R = red, Y = yellow, O = orange (skin and flesh color). Increasing color intensity is indicated by number prefix (1 = light to 6 = very intense). [y]Average of 20 trials. [x]Average of two trials. [w]Average of 26 trials.

Table 8. Yield and other characteristics of advanced yield trial entries (high-starch group), AVRDC 1985.

Entry	Marketable Yield (t/ha)				Dry Matter[z] (%)	Protein (%) (DWB)	Starch (%) (DWB)	Root Characters[y]	
	'84 summer	'84 summer	'84 fall	mean				skin color	flesh color
CN 1028-15	26.4 a	15.3 a	48.0 ab	29.9	24.8	4.7	67.1	R3	O3Y3
CN 1219-1	22.5 ab	10.4 bc	41.2 c	24.7	28.4	4.1	67.2	Y4	Y5
CN 1232-9	21.5 ab	13.0 ab	52.1 a	28.9	28.7	4.1	67.9	Y2	Y2
Tainan 17	20.1 b	8.7 c	12.6 e	13.8	27.8	-	65.3	Y4R1	Y1
Tainan 18	3.7 c	8.7 c	37.8 c	16.7	28.8	5.5	74.0	R5	R4
TN New 31	4.9 c	13.1 ab	46.4 b	21.5	27.1	3.9	71.3	R6	Y1

[z]Mean of two trials. [y]R = red, Y = yellow, O = orange. Increasing color intensity is indicated by number prefix (1 = light, 6 = very intense).

Results and Discussion

Table 8 shows the yield and other horticultural characters of the entries compared to the check cultivars. In general, yield in the summer was lower than in the fall season; but the breeding lines largely outperformed the local checks during this adverse period. Only Tainan 17 and TN 67 (not listed because of incomplete chemical data) had yields in the first summer trial that were comparable to most of the breeding lines, except CN 1028-15. In the second trial, only TN 67 and TN New 31 gave yields that were comparable to those of the breeding lines. In the fall trial, clone CN 1232-9 outyielded all entries except CN 1028-15. Among the check cultivars, only TN New 31 yielded as well as most of the test clones.

Dry matter of most breeding lines was similar to those of the check cultivars. CN 1028-15 had the lowest dry matter and starch content among the test clones. The starch content of the breeding lines tended to be higher, if not similar, to that of the high-starch check cultivar, Tainan 17, but lower than those of the other checks.

Fig.1 shows a graphical representation of marketable yield as related to the stability of clonal performance. In this trial a stable, high-yielding clone was defined as one which yielded higher than the average of all entries (bounded at the upper end by one standard deviation from the grand mean) and with a regression coefficient not statistically different from unity (bounded on the upper and lower end by half a standard deviation above and below b=1, respectively).

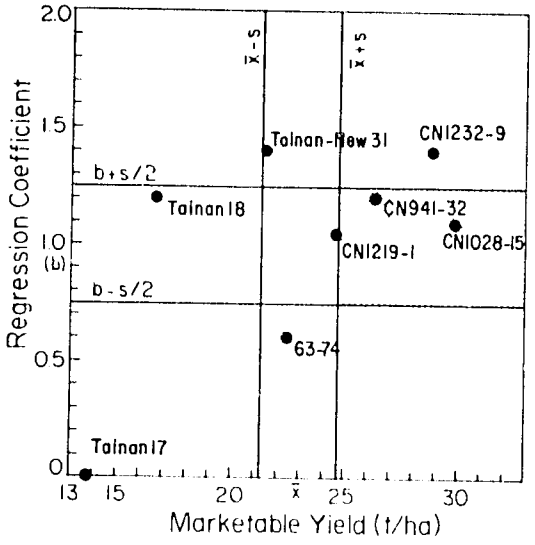

Fig. 1.
Relationship of marketable yield and stability among high-starch entries in the advanced yield trial, AVRDC, 1984.

The high-yielding, stable clones are expected to fall in the lightly shaded region to the right of Fig. 1. As may be noted, three clones, CN 941-32, CN 1028-15, and CN 1219-1, fell in this region. The best clone in terms of average yield in three environments was CN 1028-15. However, as already noted in Table 8, this clone had the lowest starch content among the breeding lines. Therefore, the best cultivars should be CN 941-32 and CN 1219-1. Starch content of CN 941-32 in these three trials was not available, however. CN 1219-1 showed a high starch content, although its average yield, falling essentially at the upper end of the average yield boundary or the lower end of the high yield limit, was not very high.

CN 1232-9 proved to be a high yielding clone with the highest starch content. However, it is relatively unstable, tending to yield better under the more favorable fall environment and perform poorly during the adverse summer season as compared with the other lines. Local check cultivars could be largely classified as average or below average yielders in these advanced tests. The most inferior check was Tainan 17 which yielded very poorly in almost all environments sampled, except in the first summer trial.

Conclusion

In terms of yield stability, three (or possibly four) may be considered as stable high yielders. The best performer, CN 1028-15, had a generally low starch content, however. Local check cultivars tended to have only average or below average yields. Lowest yields were generally obtained in the adverse summer season when local cultivars did relatively poorly compared to the breeding lines.

Performance of New Clones in the Advanced Yield Trials

Introduction

All selections from the preliminary yield trials are eventually entered in the advanced yield trials (AYT). Since sweet potato clones vary greatly in performance across environments, the AYTs are normally carried out for at least two of the three seasons (fall, summer, and spring) at AVRDC. The final set of outstanding clones are chosen on the basis of the combined performance in the AYTs and earlier trials and are entered in the multilocational trials in Taiwan. In 1984-85, we carried out the AYT trial series on clones that were advanced from the 1984 PYTs and AYTs in order to select the new clones for inclusion in the 1986 multilocation trials.

Materials and Methods

A total of four advanced yield trials were conducted in 1984-85. The trials included one in the 1984-85 fall season, one in spring 1985, and two in summer 1985. The 1984 fall AYT was planted on 29 September 1984 and harvested on 1 March 1985. The design was randomized complete block with three replications. Each plot consisted of two rows, each 8 m long, with spacings of 1 m between rows and 25 cm between plants within the row. The entries were divided into four groups. Group A and B were mainly dessert/staple type selections consisting of seven and nine test clones, respectively.

Common check cultivars for each group were CN 1108-13, MS 35-2, and TN 66. Group C and D were industrial/feed type selections composed of seven and eight test clones, respectively. The common check cultivars for these groups were CN 1232-9, CN 9038-16, and Taman 17. All clones tested in these trials came from the 1983 summer and fall PYTs and the 1984 summer AYT. The 1984 fall AYTs were duplicated in the farmer's field in Matou.

The 1985 spring AYT was carried out to evaluate selections from the 1984 summer and fall PYTs. The selections were divided into four groups but not strictly classified into any particular utilization type. The number of entries were 10, 10, 12, and 12 selections for Groups A, B, C, and D, respectively. Common check cultivars for all groups were CN 1108-13 and 1981 (TN 66). The experimental design for this trial was randomized complete block with three replications. Each plot consisted of a single 6 m long row, with rows 1 m apart and plants within the row, 25 cm apart. The trials were planted on 27 March and harvested on 27 August 1985.

Two summer AYTs were conducted in 1985. The first set comprised clones that were taken from the 1984 summer and fall AYTs. Total entries were divided into two groups: Group A consisted of nine clones compared with three check clones, CN 1232-9, CN 1108-13, and TN 66; Group B was also made up of nine clones which were compared to the same check cultivars. Each plot had a single row, 8 m long, with rows spaced 1 m apart and plants within the row, 25 cm apart. These trials were planted on 10 May and harvested on 5 November 1985.

The second set of summer trials was carried out to further evaluate the elite and secondary selections from the 1984 summer and fall PYTs (see previous section). The test clones were divided into four groups: Group A consisted of 11 elite clones compared with three check clones, CN 1232-9, CN 1108-13, and TN 66; Group B was made up of 10 elite clones compared with the same check cultivars; Group C consisted of 11 secondary selections; and Group D comprised nine secondary selections, both tested against the same check cultivars as in the first two groups. All trials were planted on 11 July and harvested on 23 December 1985.

The chemists were provided with samples from all advanced yield trials above to analyze their chemical compositions such as dry matter, starch, sugar, fiber, and beta carotene, as the case may be.

Results and Discussion

Tables 9 and 10 summarize the yield and other characteristics of the dessert/staple type selections that compared well with the check cultivars in the 1984 fall AYT. Significant yield differences were apparent in the trial at AVRDC but not in Matou. Although lower yielding than CN 1423-438, CN 1419-139 in Group A appeared to be more promising as its visual root characters such as shape, uniformity, size and flesh color, and its chemical composition for dry matter, sugar content, starch content, and fiber, are generally comparable to TN 66, a local cultivar considered to be of excellent eating quality.

In Group B, all reasonably good yielding selections had orange flesh color, although the intensity (O3Y3) was less than that of TN 66 (O4Y3). With the exception of CN 1423-170 which had a relatively low dry matter, the Group B selections compared well with TN 66 for most chemical parameters.

The best industrial/feed selections are shown in Tables 11 and 12. In the Group C trial the yields of the selections and the check cultivars were, by and large, similar except that of the low yielding check clone, Taman 17 (Table 11). However, check clone CN 1232-9 tended to be the best yielder among the entries. In terms of dry matter/starch production which are premium characters for industrial/feed type cultivars, the selections were generally superior to the check cultivars. Except clone CN 1310-5, the selections tended to have lower protein content than Taman 17.

Table 9. Yield and other characteristics of promising advanced yield trial (Group A) entries at AVRDC fall 1984.

Entry	Market Yield (t/ha)			Dry Matter		Prot.	Starch	Sugar	Fiber	Root Characters[z]					
	AVRDC	Matou	mean	(%)	(t/ha)	(% DWB)	(% FWB)	-(% DWB)-		unif.	size	shape	cr.	sk.c.	fl.c
CN 1423-438	38.0 a	47.5	42.8	27.3	10.3	2.9	17.6	14.4	1.0	G	M	MS	none	O2Y3	Y3O2
CN 1419-139	30.2 ab	40.2	35.2	33.7	10.2	4.1	21.3	12.6	1.5	G	M	SS	slight	R5	O4Y3
CN 1108-13(Ck)	39.0 a	51.1	45.0	28.1	11.0	4.6	18.7	12.1	1.1	F	L	MS	severe	O3Y3	O3Y3
AIS 35-2(Ck)	16.8 c	54.7	35.8	26.6	4.3	5.8	14.6	16.9	2.2	P	S-M	SP	severe	O6	O6
TN 66 (Ck)	31.1 ab	47.2	39.2	31.4	9.8	5.4	18.9	10.1	1.3	F	L	LS	severe	O4	O4Y3

[z]cr = cracking; sk.c = skin color; fl.c. = flesh color; G = good; F = fair; P = poor; S = small; M = medium; L = large; MS = massive; SP = spindle; SS = short spindle; LS = long spindle; SP/I = spindle/irregular; C = cylindrical; R = red; Y = yellow; O = orange. Increasing color intensity indicated by numbers (1 = light to 6 = very intense).

Table 10. Yield and other horticultural characters of promising advanced yield trial (Group B) entries at AVRDC, fall 1984.

Entry	Market Yield (t/ha)			Dry Matter		Prot.	Starch	Sugar	Fiber	Root Characters[z]					
	AVRDC	Matou	mean	(%)	(t/ha)	(% DWB)	(% FWB)	-(% DWB)-		unif.	size	shape	cr.	sk.c.	fl.c.
CN 1423NL-3	32.1 b-d	36.9	34.5	32.0	10.2	3.1	20.6	12.0	1.2	G	M	SS	none	O3Y3	O3Y3
CN 1423-170	36.8 ab	32.3	34.5	28.6	10.5	3.2	17.3	14.0	1.7	F	S-M	MS	none	Y1	O3Y3
CN 1424-36	33.6 bc	44.1	38.8	30.6	10.3	3.5	18.8	12.8	1.8	F	M	SS	none	R2	O3Y3
CN 1108-13(Ck)	42.8 a	47.6	45.2	31.0	13.2	3.3	20.8	11.0	1.0	F	L	MS	severe	O3Y3	O3Y3
AIS 35-2	31.1 b-e	43.6	37.4	27.5	8.4	3.8	15.3	17.6	1.9	F	S-L	SP	severe	O6	O6
TN 66	35.0 bc	50.9	42.9	32.1	11.2	4.3	19.9	10.4	1.1	F	L	LS	severe	O4	O4Y3

[z]For footnote, please see Table 9.

Table 11. Yield and other horticultural characters of promising advanced yield trial (Group C) entries at AVRDC, fall 1984.

Entry	Market Yield (t/ha)			Dry Matter		Protein	Starch	Sugar	Fiber	Root Characters[z]				
	AVRDC	Matou	mean	(%)	(t/ha)	(% DWB)	(% FWB)	-(% DWB)-		unif.	size	shape	sk.c.	fl.c.
CN 1345-8	48.3 ab	44.2 cd	46.2	34.6	16.7	3.6	23.2	11.3	1.1	G	L	SP	Y4	Y1
CN 1407-8	54.7 a	60.5 a-c	57.6	32.2	17.7	2.5	22.3	11.4	0.8	G	L	SP	Y4	Y2
CN 1310-5	47.4 ab	56.3 bc	51.8	32.4	15.3	4.5	22.2	11.0	1.0	G	L	SP	Y2R	Y2
CN 1232-9(Ck)	51.1 a	71.3 ab	61.2	28.4	14.5	3.7	17.8	12.7	1.3	G	S	SP	Y3	Y1
CN 1038-16(Ck)	47.2 ab	47.0 cd	47.1	28.1	13.3	2.5	18.1	15.9	1.0	F	L	SP/I	Y4R1	Y3P1
Tainan 17(Ck)	30.9 de	35.2 d	33.0	26.2	8.0	4.8	14.0	17.0	2.8	G	L	C	R1	Y2

[z]For footnote, please see Table 9.

Table 12. Yield and other horticultural characters of promising advanced yield trial (Group D) entries at AVRDC, fall 1984.

Entry	Market Yield (t/ha)			Dry Matter		Prot	Starch	Sug	Fiber	Root Characters[7]					
	AVRDC	Matou	mean	%	t/ha	% DWB	% FWB	% DWB		unif	size	shape	cr	sk.c	fl.c
CN 1388-7	42.3 de	53.1 a-c	47.1	34.2	14.5	4.0	23.5	10.5	0.9	G	L	SP	none	Y4	Y2
CN 1405-14	44.9 cd	58.9 ab	51.9	34.1	15.3	3.2	23.2	10.9	0.9	F	L	SP	none	Y4	Y2
CN 1232-9	58.8 a	69.2 a	64.0	29.4	17.3	3.4	18.8	11.7	1.6	F	L	SP	none	Y4	Y1
CN 1038-16(Ck)	46.7 cd	31.0 ef	38.8	26.7	12.5	2.7	17.1	16.3	0.9	F	M-L	MS	none	Y4R1	Y3P1
Taiwan-17	31.0 fg	29.7 f	30.3	28.4	8.9	4.8	15.0	18.2	2.7	F	L	LS	none	Y4R1	Y2

[7]For footnote, please see Table 9

In the Group D trial, a similar trend was observed when selections were compared to the checks; selections tended to have higher dry matter/starch production, lower sugar, and lower fiber content (Table 12). In productivity, most of the selections compared favorably with the high-yielding check clones, CN 1232-9 and CN 1038-16, but the yield superiority of CN 1232-9 (especially in the AVRDC trial) was more apparent.

Results of the 1985 spring AYT series are presented in Tables 13, 14, 15, and 16. Generally, yields in all trials were low because of severe weevil infestations and partly wet conditions for root growth and development. As no chemical analyses were available on these materials which were harvested in the middle of the wet season, comparisons between the selections and the check cultivars were made only for yield and general root characters.

Table 13. Yield and other characters of the best entries in the advanced yield trial (Group A) at AVRDC, spring 1985.

Entry	Marketable		Root Characters[7]			
	yield (t/ha)	root (no.)	unif	size	shape	fl.c.
CN 1517-122	10.6	64	G	M	SP	Y3O1
CN 1525-11	9.5	62	F	S-M	MS	Y5
CN 1525-22	9.1	61	G	S-M	SP	O4Y3
CN 1108-13 (ck)	8.7	56	F	S	SP	O3Y3
TN 66 (Ck)	7.1	75	F	S	LS	O4Y3

[7]For footnote, please see Table 9

Table 14. Yield and other horticultural characters of the best entry in the advanced yield trial (Group B) at AVRDC, spring 1985.

Entry	Marketable		Root Characters[7]			
	yield (t/ha)	root (no.)	unif.	size	shape	fl.c.
CN 1510-116	28.5 a	252 a	G	S	LS	O3
CN 1108-13 (Ck)	17.6 b	103 b	G	S-M	SP	3Y3
TN 66 (Ck)	8.6 c-e	75 b-d	P	S-M	LS	O4Y3

[7]For footnote, please see Table 9

Table 15. Yield and other characters of the best entries in the advanced yield trial (Group C) at AVRDC, spring 1985.

Entry	Marketable		Root Characters[7]				
	yield (t/ha)	root (no.)	unif.	size	shape	sk.c.	fl.c.
CN 1589-22	13.5 a	94 a	G	M	SS	Y3	Y1
CN 1508-265	10.6 ab	96 a	G	S	SP	Y3R1	Y2
CN 1524-65	10.4 ab	83 a	G	S-M	SP	Y4	Y2
CN 1489-43	10.3 ab	55 ab	G	S	SP	Y3	Y2
CN 1108-13 (Ck)	14.6 a	90 a	F	S	SP	O3Y3	O3Y3
TN 66 (Ck)	5.5 bc	57 ab	G	S	LS	Y4R1	O4Y3

[7]For footnote, please see Table 9

Table 16. Yield and other horticultural characters of the best entries in the advanced yield trial (Group D) at AVRDC, spring 1985.

Entry	Marketable		Root Characters[z]				
	yield (t/ha)	root (no.)	unif.	size	shape	sk.c.	fl.c.
CN 1345-8	13.0 a	84 bc	G	S-L	SP	Y3	Y1
CN 1438-13	12.0 a	109 ab	G	S-M	SP	Y3	Y2
CN 1108-13 (Ck)	11.3 ab	73 bc	F	S	SP	O3Y3	O3Y3
TN 66 (Ck)	5.5 c-d	55 cd	G	S	LS	Y4R1	O4Y3

[z]For footnote, please see Table 9.

Table 17. Yield and other horticultural characters of best entries in the 1985 advanced yield trial (Group A) at AVRDC, summer 1985 (AYT-I).

Entry	Marketable		Root Characters[z]			
	yield (t/ha)	root (no.)	unif.	grade	sk.c.	fl.c.
CN 1345-8	11.1 a	123 a	F	A	Y2R1	Y1
CN 1423-438	8.0 b	85 b-d	F	B	Y3R1	Y4O2
CN 1423-215	6.4 bc	114 ab	F	C	O3R1	Y4O1
CN 1108-13 (Ck)	5.3 cd	86 c-d	F	-	O3Y3	O3Y3
CN 1232-9 (Ck)	5.2 cd	93 a-c	G	-	Y3	Y1
TN 66 (Ck)	3.0 de	69 cd	F	-	Y4R1	O4Y3

[z]For footnote, please see Table 9.

In Group A, none of the selections significantly outyielded the check cultivars (Table 13). One selection, CN 1525-22, had similar flesh color (O3Y3) as TN 66 and may have potential as a dessert/staple type cultivar because of its good general uniformity and small to medium sized roots. In Group B one selection, CN 1510-116, outyielded the check clones and showed good root characteristics for dessert/staple purposes (Table 14). However, its orange color (O3) was less dark than that of the highly preferred TN 66 which is normally O4Y3. More selections outyielded TN 66, but not CN 1108-13, in the Group C and D trials. However, the flesh of most of the selections was yellow, indicating that they likely contain lower beta carotene than either of the check clones.

As normally expected, yields of trials planted in the summer were generally low because of adverse wet conditions that are inimical to root development. Weevil infestation in the summer trials was also very severe. Among Group A entries, CN 1345-8 gave the highest yield; but two other clones yielded higher or at least equal to the checks which invariably showed extremely low yields (Table 17). Generally, the selections had yellow flesh with only fair uniformity. None of the selections in the Group B trials significantly outperformed the check cultivars.

Yields of entries in the second summer AYT series which were planted in July were generally better than in the first summer trial (described above). The best clones in Group A are shown in Table 18. Highest yield was obtained from CN 1517-139 which also showed acceptable root characters. In Group B, two selections significantly outyielded most of the check clones (Table 19). Of these, CN 1517-142 may have nutritionally the best Vitamin A potential because of the dark orange color (O5) of its flesh. It also showed generally acceptable root characters such as good uniformity, medium root size, and long spindle shape which are considered important traits for dessert-type cultivars.

Conclusion

A number of selections outperformed the check cultivars in most of the trials and selection of the best entries either for further advanced trials or for inclusion in the 1986 multilocation trials will be carried out, once all relevant data are available. The latter test especially would have to await a more thorough treatment of all available agronomic and chemical data. Most of the required chemical and eating quality analyses have not been done to date.

Generally, performance of all clones was low in the summer trials because of adverse hot-wet conditions. Weevil infestation was also very severe in the spring and summer trials. Undoubtedly, there is a need to remove the confounding effect of weevil infestation in order to make the selection

of outstanding clones more effective. In a year-round cropping, such as in the sweet potato breeding field, pest management will have to be given more attention in 1986.

Table 18. Yield and other horticultural characters of promising clones in the 1985 advanced yield trial (Group A), summer 1985 (AYT-II).

Entry	Marketable		Root Characters[z]				
	yield (t/ha)	root (no.)	unif.	size	shape	sk.c.	fl.c.
CN 1517-139	54.1 a	234 a	G	M-L	LS	Y3O1	Y2
CN 1449-26	20.3 b	186 ab	G	S-M	SS	Y3R1	Y1
CN 1489-22	19.7 b	179 ab	G	S	R	Y2	Y1
CN 1448-49	17.3 bc	231 ab	G	S	SS-R	R4	O3Y3
CN 1532-3	15.1 b-d	172 ab	F	S	SP	Y6	Y2
CN 1108-13 (Ck)	14.2 b-e	152 bc	F	S-M	MS	O3Y3	O3Y3
CN 1232-9 (Ck)	2.3 c-e	117 b-e	G	S	SP	Y4	Y2
TN 66 (Ck)	9.4 e	82 de	P	S-M	LS	O3R1	O4Y3

[z]For footnote, please see Table 9

Table 19 Yield and other horticultural characters of promising clones in the 1985 advanced yield trial (Group B), summer 1985 (AYT-II).

Entry	Marketable		Root Characters[z]				
	yield (t/ha)	root (no.)	unif.	size	shape	sk.c.	fl.c.
CN 1510-25	27.7 a	259 a	G	S-M	LS	Y4R1	Y2
CN 1517-142	21.8 ab	148 bc	G	M	LS	O3R1	O5
CN 1108-13 (Ck)	20.8 bc	152 bc	G	S-M	MS	O3Y3	O3Y3
CN 1232-9 (Ck)	12.0 d-f	96 c-e	F-G	M-L	SP	Y4	Y2
TN 66 (Ck)	12.8 d-f	109 b-d	F	M-L	LS	O3R1	O4Y3

[z]For footnote, please see Table 9

Stability of Protein Content in Multilocation Trials

Introduction

The distribution of sweet potato germplasm to international cooperators is greatly hindered by strict quarantine regulations and the moral scruples of scientists who are apprehensive over the possibility of introducing dangerous pests and diseases into a particular country. Hence, AVRDC sweet potato breeders have resorted to multilocational testing within Taiwan to select clones with stable yield prior to intensive distribution to international cooperators of clean planting materials.

In 1984, the yield stability of advanced clones in nine Taiwan regional environments in two planting seasons was reported. Protein content could not be summarized in time for last year's report. Cultivars with protein contents (known to be environment-specific) which do not drastically vary across environments is also important if it is a prime consideration. The results from the 1983 multilocational trial were analyzed, therefore, for stability of protein content and yield.

Materials and Methods

The general procedures used in the 1983 multilocational trials were reported in 1984 annual report. To summarize, a total of 18 entries were tested in the summer and/or fall seasons at nine locations. The randomized complete block design with two replications was used. Plot size was 10 m^2.

For protein content analysis, two other trials were added that could not be included in last year's yield stability report. However, the number of entries was eventually reduced to 11 with complete protein data available.

Stability analysis followed the regression methods described by Finlay and Wilkinson (1963) and modified later by Eberhart and Russel (1966).*

Results and Discussion

As expected, protein content varied greatly among locations from 3.0 to 7.2% dry weight basis (Table 20). The most favorable environments for high protein expression was Taitung, Suilin, and Taipou in that order. The poorest environments were AVRDC and Taoyuan.

Table 20. Protein content of various clones in the 1983 multilocational trials.[z]

Entry	Locations											Variety Mean
	AVRDC (1)	AVRDC (2)	Taipou	Shalu	Taoyuan (1)	Taoyuan (2)	Taoyuan (3)	Taitung (1)	Taitung (2)	Penghu	Suilin	
CN 1108-13	3.2	4.8	5.4	4.8	3.6	3.4	4.8	4.7	5.7	5.2	6.4	4.7
CN 1028-15	4.0	5.5	5.2	5.8	3.1	4.6	4.4	6.8	5.5	5.2	7.0	5.2
CN 1219-1	3.0	6.4	7.5	4.2	3.5	4.6	4.9	3.8	7.8	3.8	6.2	5.1
CN 1216-10	3.1	5.0	6.6	4.5	3.6	4.5	4.4	4.7	7.2	4.9	6.7	5.0
CN 1221-1	3.0	6.5	5.8	5.4	3.2	4.4	4.3	4.7	8.3	5.2	6.4	5.2
CN 1229-2	2.5	5.3	5.5	5.1	2.8	3.2	3.6	4.2	8.4	4.4	5.9	4.6
CN 1229-14	3.4	4.6	7.1	4.2	3.2	4.4	5.0	5.2	8.1	4.8	5.5	5.0
CN 1280-3	2.6	4.8	6.1	5.2	2.6	3.2	3.4	5.0	7.2	5.2	5.7	4.6
CN 1229-16	3.0	5.7	6.3	4.0	3.2	4.0	4.5	4.6	9.2	5.0	5.7	5.0
CN 1280-4	2.6	5.6	5.9	4.8	3.0	3.2	5.2	4.0	6.8	5.0	6.8	4.8
CN 941-32	2.5	4.7	5.6	4.6	3.0	3.2	4.9	4.4	5.7	4.0	4.4	4.4
TN 57	2.8	4.6	6.7	4.6	2.0	3.1	3.4	2	6.2	4.2	5.8	4.2
Location Mean	3.0	5.3	6.1	4.8	3.1	3.8	4.4	4.6	7.2	4.7	6.1	4.8

[z]Based on percentage of dry weight basis.

The variation in protein content among clones did not seem to be as substantial as that among environments. As a matter of fact, the variation among the latter was 30% higher than that among clones. Protein content ranged from 4.2% (Taimung 57) to 5.2% (CN 1221-1) with an overall average of 4.8%.

Fig. 2 shows the relationship of protein content and stability among the clones in the multilocation trials. Clones with above-average and stable protein content across environments were defined as those falling in the shaded region to the right of Fig. 2. Its lower limit is bounded by the upper limit of the average protein content (mean + one standard deviation) and its regression coefficient is on or about b = 1 (b + one standard deviation). Two clones, CN 1229-14 and CN 1216-10, fell in this region of average stability and higher-than-average protein content.

Two clones with the highest average protein content, CN 1028-15 and CN 1221-1, both fell outside the stable region. The latter tended to have high protein content under favorable conditions but only equal to or lower protein than the average when the environment was unfavorable.

On the other hand, CN 1028-15 did not vary so much in protein content across environments as indicated by the low average regression coefficient (below 1). However, its deviation from regression (s^2d) was significant, making it relatively unstable for the trait on final consideration. TN 57, the local check cultivar, also tended to have a fairly consistent protein content, but its average protein content was generally lower than that of the mean of all the clones.

Conclusion

Variation in protein content among environments was more substantial than among clones. CN 1229-14 and CN 1216-10 had high, stable protein content. CN 1028-15, a high protein clone, had

*Finlay, K.W. and G.N. Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res. 14:742-754.

Eberhart, S.A. and W.A. Russel. 1966. Stability parameters for comparing varieties. Crop Sci. 6:36-40.

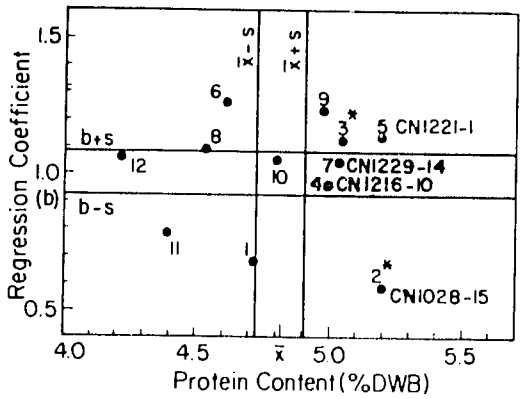

Fig. 2. Relationship between protein content and stability among clones in the 1983 multilocational trial. Significant deviation from regression is indicated by an asterisk.

consistent protein content across locations, but the deviation of values from its regression line was substantial. TN 57 also had stable protein content in all trials, but its average was generally below the mean for all clones tested.

The appreciable variation in protein content observed in this study corroborates previous reports about the difficulty of improving protein content in any breeding program. At best, the clones may have to be selected for highly heritable traits in the early stages with selection for high protein content delayed until the genotypes could be better replicated.

Selection for Early Maturity among Advanced Clones

Introduction

Sweet potato is generally a late-maturing crop and is, thus, normally difficult to fit into a multiple-cropping system. The crop is harvested at various stages but, generally, beyond 120 days to obtain good productivity. There is, therefore, a need to identify early-maturing cultivars (defined as harvestable in less than 120 days). In the AVRDC sweet potato improvement program, early bulking clones were noted from among a range of advanced breeding lines. These clones were evaluated in 1984 to corroborate the above preliminary findings.

Materials and Methods

Eight advanced clones already entered in the Taiwan regional trials were used as materials for this study. The experimental design for each of the three harvest periods (120, 150, and 180 days after planting) was randomized complete block with three replications. Each harvest period was considered a separate experiment. One of the harvest periods was actually part of the five-month regional yield trial.

Plots consisted of two rows, 8 m long, with rows 1 m apart and plants within the row, 25 cm apart. As this was only a cursory evaluation of maturity, the earliest harvest period was set at 120 days. Yield and other horticultural characters were recorded during the harvest periods and compared to determine the pattern of yield and growth for each clone.

Results and Discussion

Fig. 3 shows the marketable yield increase among clones harvested at different stages. TN 67, CN 1232-9, TN 66, CN 942-7, and TN 64 all showed the typical yield increment pattern common to many sweet potato cultivars, i.e., increasing yield over time. In contrast, clones CN 941-32, CN 1108-13, and CN 1219-1 all showed none or only a slight yield increase when harvested beyond 120

days. These clones may be classified therefore, as comparably early-maturing. The best among them was CN 941-32 with the highest yield at 120 days after planting.

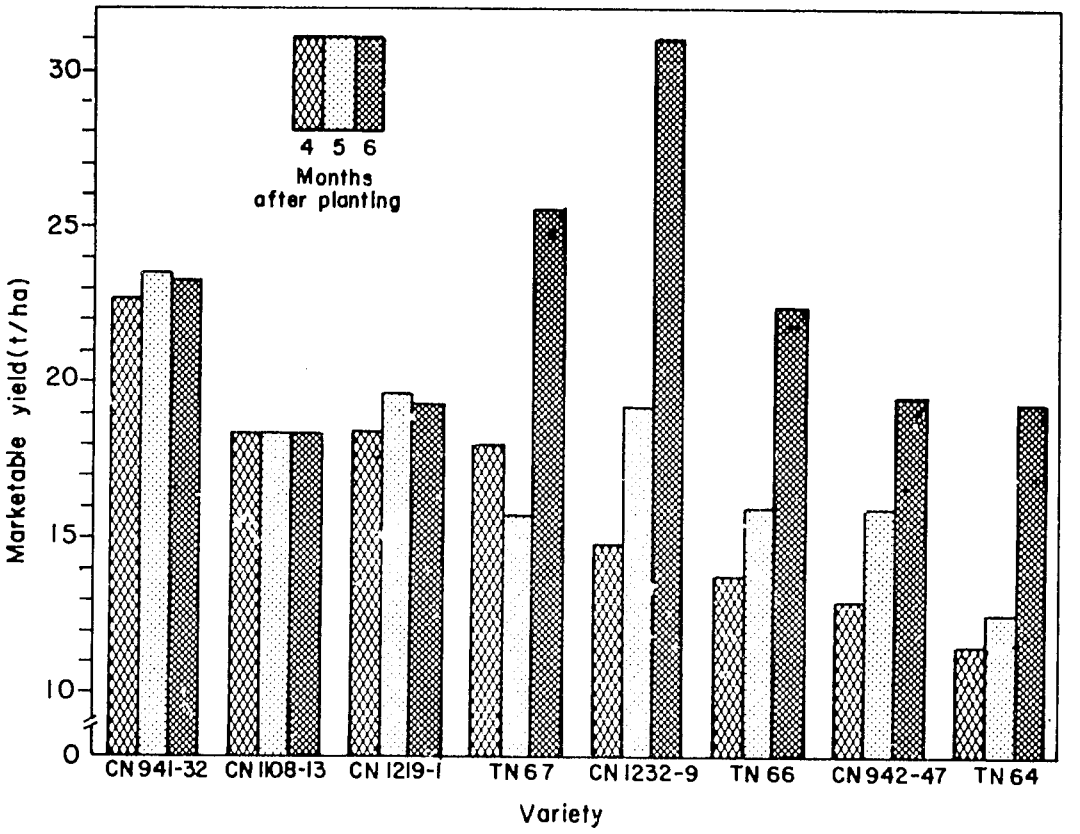

Fig. 3. Marketable yield of different clones at various harvest periods (4,5,and 6 months after planting).

Table 21 compares the other horticultural characters of the clones at three harvest dates. No definite trend was observed, but it appeared that the early maturing clones tended to reach maximum vine growth at 120 days. In contrast, CN 1232-9, the highest yielder among the late maturing clones, attained maximum growth at six months.

Among the early maturing clones, CN 941-32 achieved high yield by rapid bulking of fewer roots. On the other hand, the other early maturing clones achieved high early yield by producing more roots of obviously small unmarketable sizes, especially in clone CN 1219-1. TN 67, also a high early yielder, but late maturing in the sense that it continued to increase its yield over time, also produced numerous small roots.

Conclusion

Three clones, CN941-32, CN1108-13, and CN1219-1, produced the highest early yields. These clones did not show any substantial increase in yield when allowed to grow longer. Of these early-maturing clones, CN 941-32 achieved high early yield by rapid bulking of relatively few roots. On the other hand, the other early-maturing clones obtained high yield by producing more roots of small sizes. The early-maturing clones also tended to achieve maximum vine growth in 120 days.

Table 21. Comparative horticultural traits among clones harvested at different stages, AVRDC 1984.

Entry	Maturity Type	Top Weight (t/ha)			Marketable Root (no. × 1000/ha)			Cull Root (no. × 1000/ha)			Top/Root Ratio		
		4 mo	5 mo	6 mo	4 mo	5 mo	6 mo	4 mo	5 mo	6 mo	4 mo	5 mo	6 mo
CN 941-32	early	19.6 a	7.7 a	13.4	98 bc	102 ab	117	39 c	35 cd	38	0.8 ab	0.4 b	0.6
CN 1108-13	early	14.0 a-c	8.1 a	12.2	116 b	99 ab	106	100 a	62 bc	41	0.6 bc	0.4 b	0.7
CN 1219-1	early	12.8 bc	8.7 a	11.1	143 a	125 a	112	104 a	67 b-d	52	0.6 bc	0.4 b	0.5
IN 67	late	10.1 bc	4.0 b	10.0	146 a	94 bc	157	122 a	91 a	61	0.5 c	0.2 c	0.4
CN 1232-9	late	11.2 bc	8.0 a	16.2	87 c	101 ab	126	70 b	55 b-d	41	0.7 bc	0.4 b	0.5
IN 66	late	8.9 c	6.9 a	11.7	92 bc	93 bc	116	67 b	55 b-d	44	0.6 bc	0.4 b	0.5
CN 942-7	late	15.6 ab	8.4 a	13.6	62 d	68 c	73	39 c	32 d	40	1.0 a	0.5 ab	0.6
IN 64	late	10.5 bc	8.0 a	13.2	85 cd	91 bc	113	63 bc	65 b	41	0.7 bc	0.6 a	0.6
Grand Mean		12.8	7.7	12.7	104	97	115	75	56	45	0.7	0.4	0.5
CV (%)		25.8	19.3	15.9	13	15	22	19	27	23	22.1	16.5	30.5

Performance of Leaf-Tip Clones

Introduction

The consumption of sweet potato leaf tips or shoots as a vegetable in Asia is commonplace. In countries that do so, the cultivars commonly used are also those grown for roots. The AVRDC sweet potato improvement program, therefore, included among its objectives the development of clones with good potential as a leafy vegetable. In the last few years, a number of such clones have already been identified by the breeders. To confirm their true potential as a leafy vegetable and to select promising clones for multilocational tests, a trial was conducted in 1984.

Materials and Methods

Twelve entries (including two checks) were planted in a randomized complete block design on 6 June 1984. Each plot consisted of two rows, each 4 m long and 0.5 m apart, with a spacing of 25 cm between plants within the row. The experiment was replicated three times.

Harvesting of 10-cm-long leaf tips were carried out every two weeks from 50 to 100 days after planting. Tip yield, plant and leaf characters, and acceptability were recorded for each entry. Eating quality was first assessed by a panel of six testers for general acceptability and tenderness. The sweet potato tips were stir-fried without salt and spices.

Results and Discussion

Table 22 shows the yield and horticultural characters of the leaf-tip clones that were selected for the 1985 multilocation trial. The best yielders of fresh leaf tips were I 426 (check cultivar introduced from the Philippines) and a breeding line, CN 1370-7. Both entries were not rated tender after cooking, however, but their eating quality was considered at least good. CN 1370-7 yielded nearly twice as many tips per hectare than I 426, indicating that the latter had lighter and fewer leaves. CN 1367-2, a check breeding line that was distributed to international cooperators, proved to be tender and well accepted, but its average yield was lower than that of other entries, except CN 1364-24.

Conclusion

All clones were rated at least good in terms of acceptability, although tip tenderness after cooking was not similar. The evaluation of acceptability after cooking was considered not sufficiently exhaustive to allow a truly valid conclusion and should be expanded in future evaluations of the selected lines.

Table 22. Tip yield and other characteristics of leaf-tip sweet potato clones selected for regional yield testing, AVRDC 1984-85.

Entry	Tip Yield per Hectare		Plant Type[y]	Leaf Color		Tender ness	Eating Qlty.[v]
	no. (x 1000)	fresh wt[z] (t)		young plt.[x]	mature[w]		
CN 1364-24	2.55 c	12.0 cd	SP	YG + LP	G	slight	B
CN 1370-7	4.53 a	20.4 a	B	YG + LP	G	none	A-B
CN 1397-3	1.96 d	15.6 b	B	YG + LP	G	tender	B-C
CN 1367-2 (Ck)	2.90 c	12.8 c	P	YG	YG	tender	B
I 426 (Ck)	2.44 c	0.4 a	SP	YG	YG	none	B
Grand Mean	2.66	12.7					
CV (%)	9.70	11.1					

[z]Total of five harvests (24 Aug., 7 Sept., 20 Sept., 8 Oct., and 22 Oct. [y]SP = semi prostrate, B = bush type; P = prostrate. [x]YG + LP = yellowish green with light purple tinge; YG = yellowish green. [w]G = green; YG = light green. [v]Rated on an A to D scale; A = excellent, B = good, C = poor.

International Cooperation

The international distribution of sweet potato planting materials for widespread testing of improved genetic materials has always been a problem. Our plant physiologists and virologists have improved the system by developing pathogen-tested planting materials from tissue-cultured meristems. In 1985, a total of 264 packages of these materials was distributed to 43 cooperators in 31 countries. Later, a more thorough and efficient system was developed. Distribution will resume when new materials from the new scheme become available in 1986.

The intensive distribution of the most advanced clones in the program commenced two years ago, but feedback from international cooperators on the performance of these materials has been scanty. In most cases, we merely received indications that the materials were still only in the multiplication stage. The few completed trial reports we received are given below.

Philippines. The AVRDC Philippine Outreach Program in Los Baños announced the official release of breeding line CI 693-9. This clone is now locally known as 'BPI-Sp2'. Details of the characteristics and performance of BPI-Sp2 is available from POP.

At the Institute of Plant Breeding of the University of the Philippines, our cooperator tested 14 clones including four from AVRDC. The trial was planted during the dry season on 22 October 1984 and harvested on 22 February 1985. The design was randomized complete block with three replications. Each plot has two rows, 6 m long, and 75 cm apart. The plants within the row were spaced 30 cm apart. Table 23 shows the performance of the best entries in the trial. As may be noted, the best-performing AVRDC clone was CN 1232-9 which also had high, stable yields in previous AVRDC trials.

Table 23. Performance of AVRDC sweet potato clones compared with local check cultivars at UP Los Baños, Philippines, 1985.

Entry	Total Yield (t/ha)	Marketable yield (t/ha)	Marketable root (x 1000/ha)	Weevil Damage (no. roots/36 plts.)
Go Wi Sia	22.6	22.4 a	78	61
CN 1232-9	17.6 ab	17.2 ab	93	84
Kinabakab (Ck1)	16.7 ab	15.8 a-c	104	81
V2-1 (Ck 2)	12.7 b-d	12.6 b-e	83	57
Grand Mean	11.6	11.0	75	62
CV (%)	31.0	30.4	29	29

In a preliminary, unreplicated trial of 39 AVRDC clones planted by the Bureau of Plant Industry (Baguio Station) on 10 April 1984, the best yielder was CN 1280-3 with an estimated yield of 96 t/ha. The yield range of the AVRDC clones was 5.2 to 96 t/ha. Five breeding lines and two accessions gave yields greater than 50 t/ha. The high-yielding lines and accessions

were (besides CN 1280-3) as follows: I 981, I 59, CN 1028-15, CN 1216-10, CN 1419-193, and CN 1229-2.

At the Visayas State College of Agriculture (VISCA) in Baybay, Leyte, nine introduced clones from AVRDC were compared in an observational trial against three clones developed at that institution. The trial was planted on 16 April and harvested on 7 August 1984. The best yielder among the introduced clones from AVRDC was Tainung 66 with a root yield of 28 t/ha. CN 1108-13 gave an estimated root yield of 24 t/ha. VSP-1, a local check, gave a root yield of 21 t/ha. Three AVRDC clones gave comparable, if not higher yields, than the best local check cultivar, VSP 1. The plant breeders at VISCA are now using some of the promising clones from the above introductions as parental stocks in their polycross breeding nursery.

Singapore. A leaf tip selection, CN 1367-2, was introduced into Singapore two years ago and the Sembawang Field Experiment Station of the Primary Production Department has been testing this clone for acceptability to the local taste. Our cooperator reported that this clone grew very well under Singapore conditions. A recent assessment of quality and acceptability indicated that it is well received in terms of taste and texture, although the color of the leaves (yellowish green) was not particularly appealing. A further assessment of quality is planned with young tips rather than the young, full-grown leaves plucked from the stems (the conventional way of using sweet potato leaves there).

Bangladesh. A brief report of the sweet potato trials conducted by the Mennonite Christian Committee (MCC) indicated that introduced cultivars, such as cvs. Tinirining and BNAS (both from the Philippines), continued to be the top yielders. AIS 0122-2 was also doing well in their trials.

Australia. In a trial of seven introduced cultivars at Darwin, Northern Territory, the Department of Primary Production reported that LO 323, an accession from AVRDC, was the highest yielder. Roots were large with a very attractive color, bright copper skin, and slightly brighter flesh. This same clone was released two years ago in the Philippines.

Taiwan. We have been conducting regional trials of selected clones in Taiwan and providing genetic materials to cooperators that were not included in the multilocation network. In 1984, a trial of 14 clones introduced from AVRDC was conducted by the Agricultural Experiment Station in Kinmen to select promising cultivars for feed and/or food purposes. The trial was planted on 22 June and harvested on 20 November. Each plot had three rows, each 5 m long and 1 m apart. Plants within the row were spaced 25 cm apart.

The best performing clones compared to the local check, Kinmen 16, are listed in Table 24. In terms of yield potential, five AVRDC breeding lines were considered for future trials. However, their eating quality did not compare well with Tainung 65 and Tainung 66, both highly preferred in the test. The two top yielders among AVRDC clones, CN 1028-15 and CN 1058-10, were both assessed as potentially good for feeds.

Table 24. Performance of AVRDC clones in Kinmen, Taiwan 1984.

Entry	Marketable Yield(t/ha)	Growth Habit	Root skin	Color flesh	Eating Quality	Potential Use
CN 1028-15	35.5	SE	red	orange	fair	feed
CN 1058-10	33.2	SE	red	orange	fair-poor	feed
I 430 (TN 65)	32.7	SE	red	orange	good	food
TN 66	32.1	E	red	red	excellent	food
CN 942-47	31.8	SE	red	orange	fair	–
CN 1108-13	31.8	SE	deep yellow	orange	fair	feed
AIS 0122-2	29.8	SE	orange	orange	fair-poor	–
K 16 (Ck)	28.9	SE	slight yellow	yellow	fair	–

Sweet Potato Entomology

Search for Germplasm Sources Resistant to Sweetpotato Weevil

Introduction

Sweetpotato weevil, *Cylas formicarius formicarius* (F) (Coleoptera: Curculionidae) is the most destructive pest of sweet potato in the tropics. The larvae and adults feed on sweet potato roots and crowns. Weevil feeding either in roots or stems does not reduce the total root yield, but the quality of infested roots is impaired even by a slight pest damage which makes the roots unfit for human consumption. In order to control this insect cheaply and effectively, screening sweet potato germplasm has been done since 1975 to identify accessions resistant to this pest. Two screening tests were conducted during 1985.

Materials and Methods

Sweet potato accessions were planted individually in a single row in 5-m-long and 1-m-wide plots between two weevil source rows in a sweetpotato weevil nursery. Ten weeks earlier, a susceptible cultivar was planted in these source rows and was infested with laboratory-reared weevils released before transplanting the test materials. The crop was grown according to traditional cultural practices, except that no insecticide was used. At harvest weevil infestation was evaluated by cutting open each root and counting the number of larvae, pupae, and adults inside.

The insect count data were converted to mean number of insects (larvae+pupae+adults) per kilogram of roots and subjected to a statistical analysis based on mean and standard deviation (sd). The following categories of resistance based on insect number were used:

Highly resistant (HR): less than mean −2sd
Moderately resistant (MR): between mean −1sd to mean −2sd
With low resistance (LR): between mean and mean −1sd,
Susceptible (S): between mean and mean + 2sd,
Highly susceptible (HS): more than mean + 2sd

Results and Discussion

Among the 66 entries included in the first test, 22 did not give adequate root yield (less than 1 kg/plot), and hence could not be evaluated. Among the remaining 44, the number of weevils per kilogram of roots ranged from 0 to 32.2. Two accessions were judged as MR; 29, LR; 9, S; and 4, HS (Fig. 1). Two MR and six LR accessions which had two or less weevils per kilogram of roots will be tested again in 1985 for weevil resistance.

Most of the entries included in the second test were recently received from Papua New Guinea. These accessions have generally low yield potential. Among the 38 entries that yielded 1 kg or more of roots per plot, the number of weevils in each kilogram of roots ranged from 0 to 93. None of the entries were HR or MR; 27 were LR; 9, S; and 2, HS (Fig. 1). Four LR entries which were free of weevil infestation will be advanced for further testing in 1985.

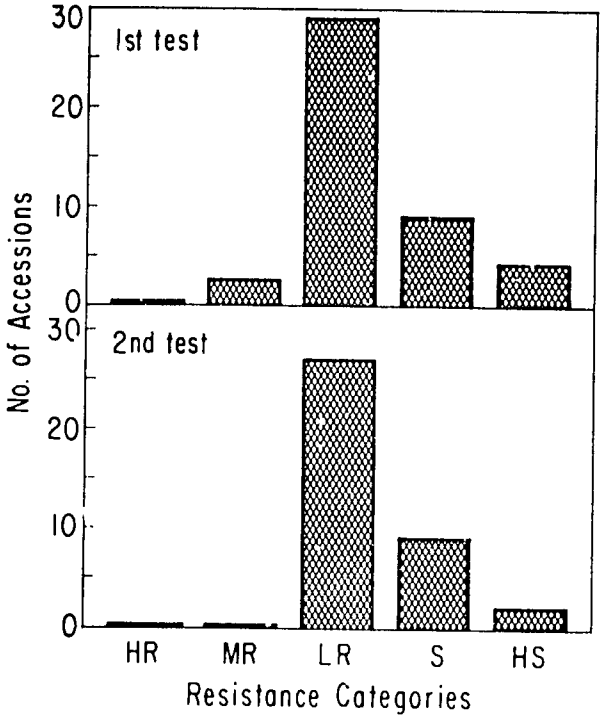

Fig. 1.
Distribution of sweet potato germplasm screened twice for resistance to sweetpotato weevil.

Conclusion

Two sets of sweet potato accessions were screened for resistance to sweetpotato weevil. Least damaged entries (eight entries in the first test and four in the second) will be evaluated further in 1986. Despite our continuing intensive screening, no accession has yet shown a consistent level of resistance.

Correlation of Root Characteristics and Root Infestation by Sweetpotato Weevil

Introduction

Although sweetpotato weevil infests stems and crowns, the major damage is done on roots which are rendered useless for human consumption. AVRDC has been screening germplasm for the past 10 years, but has not yet found an accession consistently resistant to this pest. This experiment studied the correlation between quantifiable root characters (dry matter, sugar, beta carotene, and protein) and infestation by sweetpotato weevil. These characters were actually analyzed on sweet potato roots of several seasons by AVRDC chemists.

Materials and Methods

A 0.3-ha parcel of land was rototilled, applied with basal fertilizers, and worked into 1-m-wide beds. Two months before the planting of test materials, every third row was planted to a weevil-susceptible sweet potato accession and infested with laboratory-reared weevils six weeks later to act as source of infestation.

Twenty-two accessions or breeding lines were selected for this study. Four entries with white flesh had dry matter content ranging from 17.1 to 37.1%. Four entries with orange flesh had dry matter content ranging from 19.4 to 33.7%. Five entries had total sugar content ranging from

10.6 to 31.4%. Five entries had beta carotene content ranging from 1.4 to 10.5 mg/100 g of roots, and four entries had protein content ranging from 2.0 to 9.7%.

Stem cuttings of each entry were dipped in 0.05% carboturan solution for 20 min before planting. Each entry was planted in a single row on eight plots, 5 m long and 1 m wide, between the weevil-source rows. Each plot, representing one replicate, was arranged in a randomized complete block design.

The crop was raised according to customary cultural practices, except that no insecticide was applied. At harvest we cut open each root of every entry and recorded the number of larvae, pupae, and adults found inside. The insect count data were calculated from 1 kg of roots and subjected to a linear regression correlation analysis to study the relationship between various root constituents and the number of weevils (larvae + pupae + adults).

Results and Discussion

The results of the correlation between various root constituents and sweetpotato weevil infestation are summarized in Figs. 2 to 5.

Two sets of four accessions each (one set white fleshed and the other, orange fleshed) were chosen to study the correlation of dry matter and weevil infestation. In both sets there was no statistically significant correlation between dry matter content and number of weevils in the roots (Fig. 2). In the orange roots, there were generally less weevils with increased dry matter content. This trend was not observed in accessions with white roots.

In general, more weevils were found in roots with increased concentrations of total sugar, but the correlation was not statistically significant (Fig. 3). As the concentration of beta carotene in roots increased, the number of weevils also increased, and the correlation was significant and positive between these two components (Fig. 4).

There was no significant correlation between protein content in the roots and sweetpotato weevil infestation (Fig. 5). It must be mentioned that the entries with high protein content had very low yield potential. In fact, the entry with the highest protein content at harvest had no tuberous roots in the tests. The roots when present were very small and, thus, not vulnerable to weevil infestation as it is with large roots.

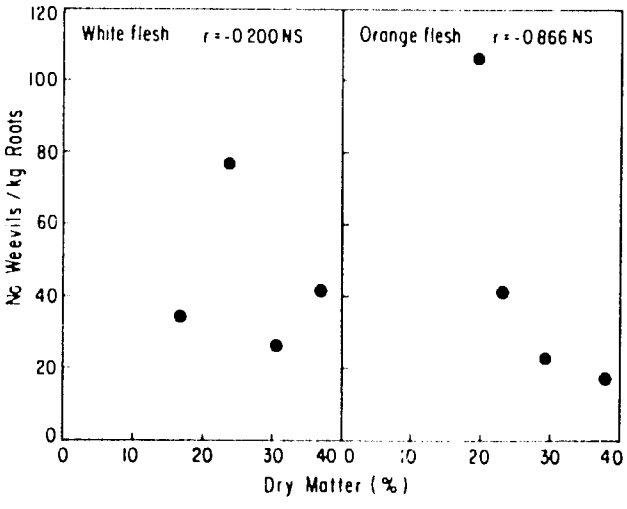

Fig. 2. Relationship of dry matter and sweetpotato weevil infestation in sweet potato roots with white and orange flesh.

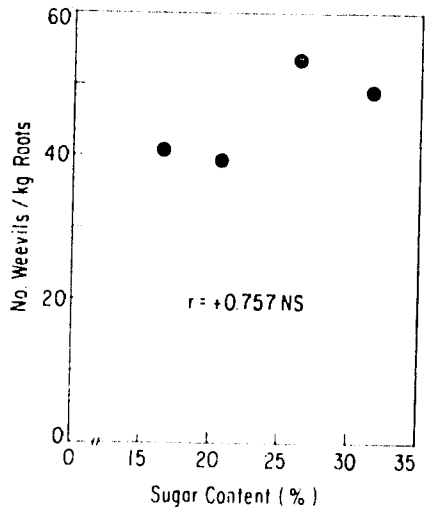

Fig. 3. Relationship between sugar and sweetpotato weevil infestation in sweet potato roots.

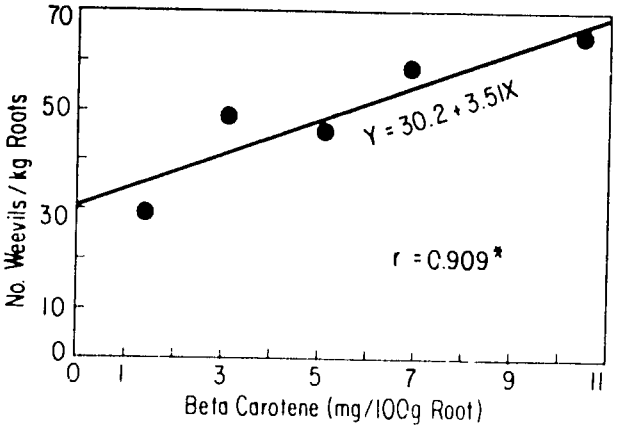

Fig. 4. Relationship between beta-carotene and sweetpotato weevil infestation in sweet potato roots.

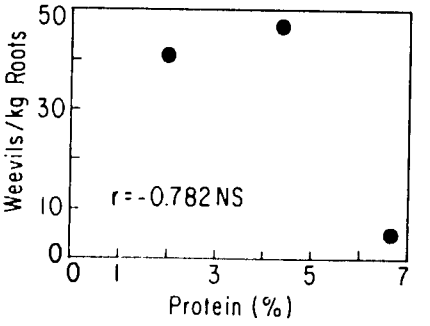

Fig. 5. Relationship between protein content and sweetpotato weevil infestation in sweet potato roots.

Conclusion

There was no statistically significant correlation between weevil infestation and dry matter, sugar, and protein contents of roots; but a significant positive correlation was observed between infestation and beta carotene content. Since wide variations in yield and weevil infestation from season to season is common in sweet potato, this experiment will be repeated over three seasons to to be able to draw definite conclusions.

Influence of Mulching on Sweetpotato Weevil Infestation

Introduction

Sweetpotato weevil, *Cylas formicarius formicarius* (F) (Coleoptera: Curculionidae) infests sweet potato roots. The major factor in weevil entry is root exposure. This could be due to the growth habit of the plant in which the roots are found near the soil surface, or to the land cracks above the roots. The cracks are mainly the result of root enlargement and low soil moisture. This experiment tried using mulch to control the weevil presumably by reducing soil cracking.

Materials and Methods

This experiment was conducted in a sweetpotato weevil nursery where every third row (1 m wide) planted to sweet potato was infested with laboratory-reared weevils prior to planting of the test materials. The 2-m-wide empty area between the weevil-infested rows was rototilled and worked into two 1-m-wide beds. Stem cuttings of sweet potato cultivar I 57 were dipped in 0.05% carbofuran solution for 20 min prior to transplanting to eliminate the weevils in the planting materials. Immediately after transplanting in September 1984 eight randomly selected 5 m x 2 m plots were covered with a black plastic sheet; eight were mulched with dried rice straws, and the remaining eight were left undisturbed as check plots. Each plot represented one replicate.

The crop was raised according to customary cultural practices, except that no insecticide was applied. In February 1985, the crop was harvested, its root yield recorded, and each root dissected open and the number of larvae, pupae, and adults recorded.

Results and Discussion

The results of the use of mulch on infestation of sweet potato roots by sweetpotato weevil are shown in Fig. 6. Both rice straw and black plastic mulches reduced sweetpotato weevil infestation of the roots. The reduction was greater in the black plastic treatment. The mulch covered the soil cracks and presumably minimized access to the roots by the sweetpotato weevil. The rice straw mulch did not cover the soil as continuous and completely as the plastic sheet, and so weevil could still get at the roots via the spaces between straws. The presence of some weevils under the plastic mulch was probably due to wear and tear on the sheet through five months of use in the field.

Another probable reason for the reduction in infestation was that mulching reduced evaporation and conserved soil moisture which in turn minimized land cracking. Since the plastic sheet provided better cover, it conserved moisture better than rice straw mulch.

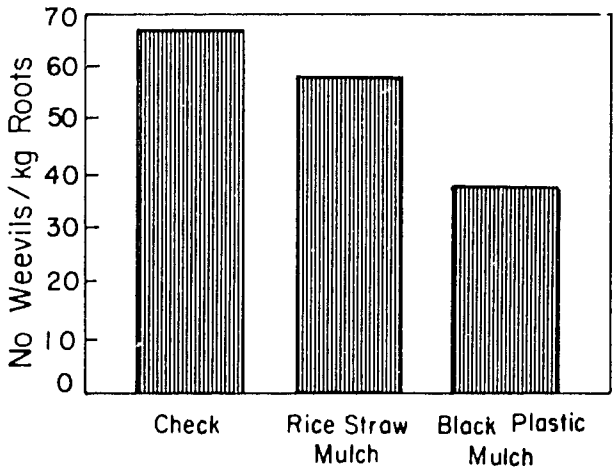

Fig. 6.
Influence of rice straw and plastic mulches on sweetpotato weevil infestation in sweet potato roots.

Although the sweet potato plants in plots covered with mulches initially grew more vigorously, there were no significant differences in root yield among all three treatments.

Conclusion

When sweet potato plots were covered with black plastic or rice straw mulches, weevil infestation was less than in the uncovered check plots.

Third Screening of Selected Sweet Potato Accessions for Resistance to Sweetpotato Vine Borer

Introduction

Sweetpotato vine borer, *Omphisa anastomasalis* Gn. (Lepidoptera: Pyralidae) is an important pest of sweet potato in Asia and the Pacific, and is especially serious in semiarid areas. The larvae bore into the vines and feed concealed inside, as a result of which, up to 50% of root yield is reduced. At times they also bore into the roots, especially those that are closer to the soil surface.

In 1981 we identified two sweet potato accessions, I 55 and I 92, which showed moderate to high levels of resistance to this pest. These accessions are now being used in the AVRDC vine borer resistance-breeding program. However, despite grafting efforts on flower-inducing stalks, they do not flower readily, thus, presenting a serious problem in cross breeding. We have, therefore, continued our search for additional sources of resistance to this pest. In 1985 we screened seven accessions which had shown low levels of vine borer damage in two previous years at Penghu island.

Materials and Methods

A 0.1-ha parcel of land was rototilled, applied with basal fertilizer, and worked into 1-m-wide beds. Stem cuttings of each of the seven apparently resistant accessions and one standard susceptible check (AIS 35-2) were planted in a single 5-m-long row on each 1-m-wide beds. Each entry had eight replicates arranged in a randomized complete block design. The crop was raised according to customary cultural practices, except that no insecticide was applied.

At harvest each plant was observed for vine borer infestation. Insect infestation can be judged by the presence of adult escape holes in the crowns and frass from larval feeding within the stem. Such frass gets accumulated on the crowns. Vine borer-infested and total number of plants in each plot were recorded, and the damage data were converted to percentage of damaged plants for comparison. The mean percentage of damaged plants in each accession was compared by Duncan's multiple range test.

Results and Discussion

The results of the screening test are summarized in Table 1. All seven apparently resistant accessions suffered various levels of vine borer infestation. All entries, except accession I 582, were free of infestation in a 1984 test. In that test I 582 had a greater percentage of damaged plants than the susceptible check. Among all entries, accession I 789 had the lowest level of vine borer damage which was statistically not significant different from that of the AVRDC standard resistant check, I 92. We will study accessions I 789 and I 92 further in 1986 to characterize their resistance mechanisms.

Conclusion

Screening of eight selected sweet potato accessions at Penghu Island resulted in the identification of one additional accession, I 789, which is resistant to sweetpotato vine borer.

Table 1. Infestation of selected sweet potato accessions by sweetpotato vine borer.[z]

Accession No.	Mean Damage (%)	Accession No.	Mean Damage (%)
I 789	7.6 d	I 656	33.0 c
I 92[y]	21.2 cd	I 695	45.1 bc
I 780	32.1 c	AIS 35-2[x]	65.0 ab
I 708	32.4 c	I 582	69.4 a

[z]Data are means of eight replicates. Means in the vertical column followed by the same letter are not significantly different at the 5% level, according to Duncan's multiple range test. [y]Standard resistant accession. [x]Susceptible check.

Sweet Potato Pathology

Screening for Resistance to Sweet Potato Scab

Introduction

Although relatively tolerant to diseases, sweet potato can be severely damaged by a few pathogens. One of the most serious diseases of sweet potato is scab, caused by the fungus *Elsinoe batatas* (Saw.) Viegos Jenkins (imperfect stage, *Sphaceloma batatas* Saw.). The disease is especially severe in tropical environments where it is favored by rainfall and high humidity.

Breeding for resistance to sweet potato scab was not initiated in the past because of the very low natural incidence of scab at AVRDC and in most areas of Taiwan. Because of its importance in many tropical countries, however, AVRDC initiated a scab resistance program this year. Field trials were conducted at Green Island and the development of the rapid *in vitro* screening methology was done at AVRDC.

Materials and Methods

The field screening trial was conducted at two locations (Chung Liao and Kung Kuan) on Green Island from March to July, 1985 with 67 cultivars from AVRDC and one local variety planted in 1 × 1.5 m plots. In seven plots test materials were planted in one row and each row was completely surrounded by at least 1 m of a susceptible local cultivar. Tip cuttings of this susceptible cultivar were infected with scab prior to planting in the experiment.

Disease severity was observed on the terminal 10-leaf portion of one vine randomly selected from each plant within a cultivar. The percentage infected area of three parts of a sweet potato vine (leaves, petioles, and stem) were recorded. The disease index for a plant was the mean of the percentage infected area of the three parts.

At the AVRDC campus, rapid *in vitro* screening tests were conducted in a closed, plastic, moist chamber (3 × 1 × 1 m) from August to October 1985. Cuttings from test and check cultivars were rooted in small plastic pots. After developing shoots, they were inoculated with a spore suspension and placed in flats in the moist chamber. Spores from the culture #25YS, isolated from infected tissues of sweet potato at AVRDC, were used as the inoculum.

Isolation was performed as follows: Pieces of infected tissue were gently rubbed against the surface of the medium supplemented with antibiotic (*Streptomycin penicillium* and *chloramphenicol*). Two days later, single germinating conidia were transferred to a fresh medium under a compound microscope. Typical slow-growing colonies started developing after several days. The inoculum was produced by growing the fungus on carrot agar (20 g carrot + 20 g agar/l) incubated in 24°C with 12 h of light and 12 h of darkness for six days.

The spores were collected by washing the surface of the medium with sterile distilled water. Two methods were used for disease evaluation. Disease incidence was recorded when infection frequency was low, and disease severity was evaluated when infection frequency was moderate to high. Disease severity was evaluated by the system described in Table 1.

Table 1. Susceptibility rating for sweet potato scab.

Position Damaged	Score[z]	Description
Shoot Tip (terminal (portion)	0	no symptom
	2.5	mild symptoms
	5	severe symptoms
Stem (upper portion from the third expanded leaf)	0	no symptom (×5%)
	0.5	5-25% diseased area
	1	25-50% diseased area
	2	more than 50% diseased area
Leaves (each of the three upper-most expanded leaves)	0	no symptom
	0.25	spot distribution localized
	0.5	spot distributed throughout a leaf
	1	spot distributed throughout a leaf plus curling or defoliation

[z]Scores for shoot tip, stem, and each of the three leaves are given for each plant. The disease index is calculated as follows: disease index (%) = summation of the shoot tip, stem, and the three individual leaf scores × 10.

Results and Discussion

In the field screening trial at Green Island, the disease severity ratings of the AVRDC cultivar ranged from 0.1 to 34.5% (local check, 33.3%) in Chung Liao and from 0.5 to 50.0% (local check 17.2%) in Kung Kuan (Table 2). In general, a higher disease severity was observed at Kung Kuan. The three reportedly resistant cultivars (V 2-1, V 2-3, and V 2-30) from the Philippines were also among the most resistant in this test. Some of the AVRDC cultivars tested had a level of resistance that was equal to or better than these cultivars.

It appears that the variation observed in the disease severity ratings under field conditions is at least partially due to the evaluation of the 10-leaf terminal portion of the vine. It is recommended that only the three-leaf terminal portion of the vine be evaluated and that more samples be assessed.

During the *in vitro* studies high infection frequency occurred under the following conditions; rapidly growing shoot cuttings, inoculum concentration above 5×10^5 spores/ml, relative humidity equal to or above 98%, and temperature below 35°C. If these conditions are maintained disease symptoms will be observed three to four days after inoculation

These conditions were not met in one experiment necessitating the evaluation of disease incidence rather than disease severity (Table 3). There were significant differences in the level of incidence among cultivars. Their resistance ratings were generally similar to those obtained from disease severity, except that cultivar I 6 was similar to V 2-30. In other tests, cv. I 6 was rated as susceptible or moderately susceptible. Therefore, rating for disease incidence does not seem to be a reliable technique.

In the other screening tests at AVRDC (Tables 4 and 5), disease severity ratings (Table 1) were used to evaluate the cultivars. The disease indices of 19 cultivars from Green Island (Green Island 1 to 19) ranged from 6.5 to 76% (Table 4). Four of the cultivars had disease indices that were not significantly different from that of the resistant check (V 2-30).

Three of these resistant cultivars (Green Island 6, 13, and 19) were retested with six AVRDC accessions and the resistant check (V 2-30) (Table 5). Again the disease indices of the Green Island cultivars were not significantly different from that of the resistant check. Also five of the six accessions had disease indices similar to that of the resistant check. These accessions were previously reported to be either resistant or moderately resistant. The accession I 6, previously reported to be susceptible to scab, had a disease index that was significantly higher than all of the other cultivars.

Apparently the *in vitro* test using the disease severity technique described here is able to differentiate levels of resistance to scab. Cultivar V 2-30 showed a high level of resistance to scab in all four tests. Other highly resistant cultivars in one or more tests were also identified.

Table 2. Screening of sweet potato cultivars for scab resistance at Green Island.

Cultivar	Disease Index[z]		Mean[y]	Cultivar	Disease Index[z]		Mean[y]
	C-L	K-K			C-L	K-K	
CN 1510-25	18.9	50.0	34.5	CN 1219-1	0.6	10.6	5.6
CN 1524-65	17.4	48.3	32.9	CN 1346-9	1.9	9.0	5.5
CN 1525-11	34.5	17.2	25.9	CN 1221-1C	7.9	2.8	5.4
Local Check	33.3	17.2	25.3	CN 1038-16	7.6	2.8	5.2
CN 1510-116	25.6	10.8	18.2	CN 1407-8	4.4	5.8	5.1
CN 1448-13	5.3	30.8	18.1	CN 1486-24	0.6	9.2	4.9
CN 1517-139	10.8	23.3	17.1	V 2-1	1.9	7.3	4.6
CN 1429-33	2.0	30.5	16.3	CN 1388-7	3.4	4.7	4.1
CN 1508-265	10.8	20.6	15.7	CN 1028-15	0.6	7.5	4.1
CN 1524-112	4.6	25.7	15.2	V 2-3	1.6	6.2	3.9
I 981	6.3	23.3	14.8	CN 1517-122	2.3	5.2	3.8
CN 1421-153	8.8	18.9	13.9	CN 1529-134	3.2	4.2	3.7
CN 1424-36	13.4	12.2	12.8	CN 1438-13	4.9	2.2	3.6
CN 1517-164	11.8	12.9	12.4	CN 1423-55	2.4	4.6	3.5
CN 1517-131	15.6	6.2	10.9	CN 1489-43	4.3	2.3	3.3
AIS 35-2	3.1	18.3	10.7	CN 1534-23	2.4	3.2	2.8
CN 1058-10	15.6	5.2	10.4	I 57	1.4	4.2	2.8
CN 1489-95	14.6	6.1	10.4	CN 1345-8	2.8	2.3	2.6
AIS 122-2	0.1	19.0	9.6	CN 1425-22	2.3	2.8	2.6
CN 1522-89	10.1	9.0	9.6	CN 1438-26	2.2	2.3	2.3
CN 1425-3	12.9	6.2	9.6	CN 1280-3	0.7	3.7	2.2
CN 1108-13	1.2	17.8	9.5	CN 1229-14	3.3	1.0	2.2
Daya	6.5	12.1	9.3	CN 1489-22	3.2	0.9	2.1
CN 1448-62	1.0	15.8	8.4	CN 1423-21	0.7	3.2	2.0
CN 1517-105	9.1	7.5	8.3	CN 942-47	2.2	0.9	1.6
CN 1216-10	7.1	8.8	8.0	CN 1229-16	0.2	2.8	1.5
CN 1489-79	9.0	6.8	7.9	CN 1232-9	0.7	2.3	1.5
CN 1449-26	7.5	8.0	7.8	CN 1433-39	0.6	2.3	1.5
CN 1525-87	12.4	2.3	7.4	CN 1280-4	0.9	1.9	1.4
CN 1517-126	3.9	9.6	6.8	CN 1229-2	0.8	1.7	1.3
CN 1424-9	3.4	8.9	6.2	CN 1310-23	1.0	1.0	1.0
CN 1309-18	8.1	3.8	6.0	CN 941-32	0.8	1.2	1.0
CN 1428-18	4.7	7.2	6.0	V 2-30	0.2	1.7	1.0
CN 1434-2	9.1	2.4	5.8	CN 1538-12	1.0	0.5	0.8

[z]Average of three plants; C-L = Chung-Liao; K-K = Kung-Kuan. [y]Average of two locations.

Conclusion

Because of the importance of sweet potato scab in tropical countries, AVRDC has initiated a scab-resistance program. The *in-vitro* screening and evaluation methodology has been developed. Using this methodology, as well as field trials, several cultivars with high levels of resistance to scab have been identified. These levels will be confirmed and the *in-vitro* methodology verified next year.

Table 3. Evaluation of scab incidence in sweet potato cultivars at AVRDC[z].

Cultivar	Infected Plant No.	Total Plant No.	Disase Incidence[y] (%)
CN 1510-25	157	188	83 a
CN 1428-18	74	143	54 b
CN 1346-9	52	135	39 bc
I 6	39	121	30 cd
V 2-30	18	82	24 cd
CN 1538-12	21	131	16 d

[z]Plants evaluated eight days after inoculation. [y]Average of two replications; mean separation by Duncan's multiple range test at the 5% level. Disease incidence = no. of infected plants/total no. of plants.

Table 4. Evaluation of disease severity by the AVRDC scab susceptibility rating system.[z]

Cultivar	Disease Index[y] (%)	Cultivar	Disease Index[y] (%)
Green Island 11	76 a	Green Island 9	59 abc
Green Island 1	72 ab	Green Island 5	59 abc
Green Island 10	72 ab	Green Island 12	56 abc
Green Island 2	72 ab	Green Island 17	53 bc
Green Island 7	70 ab	Green Island 8	49 c
Green Island 18	68 abc	Green Island 4	31 d
Green Island 14	67 abc	V 2-30	21 de
Green Island 15	64 abc	Green Island 6	19 de
Green Island 3	62 abc	Green Island 13	13 de
Green Island 16	60 abc	Green Island 19	7 e

[z]Plants evaluated one week after inoculation.
[y]Average of ten plants; mean separation by Duncan's multiple range test at the 5% level.

Table 5. Screening introduced sweet potatoes for scab resistance by the AVRDC rating system[z].

AVRDC Acc. No.	Cultivar Name	Reported Level of Resistance	Disease Severity[y]
I 6		susceptible	40.1 a
	Green Island 6	resistant	9.8 b
I-1175	V 2-30	resistant	8.6 b
I-949		resistant	7.4 b
I-951		moderate resistant	6.6 b
	Green Island 19	resistant	6.3 b
I-950		moderate resistant	5.9 b
	Green Island 13	resistant	5.4 b
I-953		resistant	4.6 b
I-948		moderate resistant	4.4 b

[z]Plants evaluated eight days after inoculation. [y]Average of two replications with 20 plants each; mean separation by Duncan's multiple range test at the 5% level.

Sweet Potato Physiology

Effect of Leaf Age on Storage Root Formation of Sweet Potato Leaf-Cuttings

Introduction

Using sweet potato leaf-cuttings to conduct physiological research, as well as produce disease-tested storage roots for international distribution, appears to be a simple system. The present study investigated the best time to get leaf-cuttings for use as planting materials.

Materials and Methods

Plants of AIS 35-2 were staked and grown in the greenhouse at one plant per pot. Leaves were tagged at the time of unfolding, and cut at the base of the petiole at different times after unfolding. Leaves with petioles were later transplanted to small plastic pots containing a sand-and-soil mixture. Two experiments were conducted: one was transplanted and sampled on 8 June and 9 August, and the other on 15 July and 8 October 1985, respectively.

Results and Discussion

Both experiments gave similar results, therefore, only the data of the July 15 planting is shown in Table 1. The results demonstrated that leaves two to three days after unfolding were able to grow properly and form storage roots.

Table 1. Effect of leaf age on the growth and storage root formation of sweet potato leaf-cuttings.[z]

Days after Leaf Unfolding	Leaf Area (cm^2)	Fresh Stge. Rt (g) per leaf-cutting	Total Dry Wt (g)	HI[y] (%)
0	46 de	1.3 c	0.78 c	27 c
1	56 d	2.4 c	1.05 c	38 bc
2	76 c	5.0 b	1.87 b	50 ab
3	79 bc	5.7 ab	2.08 b	52 a
4	83 a-c	6.1 ab	2.66 a	56 a
5	86 ab	4.5 b	1.92 b	47 ab
6	83 a-c	6.3 ab	2.20 ab	57 a
7	91 a	7.1 a	2.42 ab	58 a
8	85 a-c	5.3 ab	1.99 b	57 a

[z]Mean separation within columns by Duncan's multiple range test. [y]Harvest index on dry weight basis.

Source-Sink Relationship in Sweet Potato Leaf-Cuttings by Reciprocal Grafting

Introduction

It was previously reported that both photosynthetic source and storage root sink were important in determining final yield of sweet potato. It is, therefore, important to understand this relationship between the source, production of photosynthate in the leaf, and the sink in which dry matter is accumulated as economic yield in the roots. Knowledge of this relationship is needed to determine which of the two, the source or the sink, currently limits yields of AVRDC improved clones, and to decide on the probable steps needed to overcome this limitation. In the present investigation, rooted leaf-cuttings of four AVRDC improved clones with different yields were grafted to study the source-sink relationship.

Materials and Methods

Plants of CN 1028-15, CN 1038-16, CN 1108-13, and CN 1367-2 were first grown and staked in pots in the greenhouse. From each line, petioles without leaf blades were grown in the small plastic pots with a sand-and-soil mixture. The petioles without leaf blades were grown for two weeks for rooting and then used as stocks for grafting. Leaves with uniform size at two to three days after unfolding were used as scions and grafted to rooted petioles.

Combinations of reciprocal grafts were made to emphasize high- and low-yielding clones, including four self-grafts (Table 2). A randomized complete block design with four replications having five grafts each was employed. The grafting and harvesting of grafted leaf-cuttings were conducted on 13 June and 24 September, 1985, respectively. The grafted leaf-cuttings were observed for leaf area, and fresh and dry weights of blade, petiole, adventitious root, and storage root.

Results and Discussion

Table 2 shows the yield, leaf area, fresh storage root weight, total dry weight, and dry storage root/total dry weight of four sweet potato clones. Among four self-grafted leaf cuttings, CN 1028-15 had the highest yield of fresh storage root weight and total dry weight, and the biggest leaf area.

Table 2. Leaf area, fresh storage root weight, total dry weight, and harvest index (HI) of grafted leaf-cuttings.[z]

Grafting (scion/stock)	Leaf Area (cm^2)	Fresh Stge. Rt (g) per leaf-cutting	Total Dry Wt (g)	HI[y]
1028-15/1028-15	188 a	19.9 a	5.5 a	76 a
1038-16/1038-16	145 b-d	13.2 bc	4.4 b	68 a
1108-13/1108-13	126 d	2.9 e	2.5 c	20 d
1367-2/1367-2	167 ab	3.2 e	2.9 c	32 cd
1108-13/1028-15	127 cd	15.6 ab	3.4 bc	75 a
1367-2/1028-15	140 b-d	9.5 cd	2.9 c	52 b
1108-13/1038-16	135 b-d	15.5 ab	4.4 b	70 a
1367-2/1038-16	165 ab	9.5 cd	3.2 c	48 b
1028-15/1108-13	160 ab	12.6 bc	3.5 bc	45 b
1038-16/1108-13	153 b-d	8.6 cd	3.5 bc	43 bc
1028-15/1367-2	158 a-c	5.9 de	3.6 bc	51 b
1038-16/1367-2	152 b-d	2.3 e	2.6 c	23 d

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.
[y]HI = harvest index.

The results of Table 2 revealed that both genetic characters of source and sink could influence the storage root yield, i.e., from the stand point of source, CN 1028-15 is better than CN 1038-16,

CN 1108-12 is better than CN 1367-2; from the stand point of sink CN 1108-13 is better than CN 1367-2, but not much difference was shown between CN 1028-15 and CN 1038-16.

When both hi h yielders, CN 1028-15 and CN 1038-16, were used as stocks on the two low yielders, CN 1108-13 or CN 1367-2, respectively, fresh storage root yield and dry storage root weight/total dry weight ratio, i.e., harvest index (HI), were consistently higher than those of the self-grafted CN 1108-13 and CN 1367-2. The results suggest that the yield of storage roots was primarily determined by the sink capacity rather than the source potential.

On the other hand, when both high yielders, CN 1028-15 and CN 1038-16, were used as scions and grafted on CN 1367-2 as stock, fresh storage root weight of these grafts was comparable with that of the self-grafted CN 1367-2. Apparently, the source potential of two higher yielders did not influence the storage root formation of CN 1367-2.

However, when both high yielders, CN 1028-15 and CN 1038-16, were used as scions and grafted on CN 1108-13 as stock, fresh storage root and HI of these grafts were higher than those of the self-grafted CN 1108-13; total dry weight also tended to increase. Apparently in this case, the source potential of two high yielders, CN 1038-16 and CN 1028-15, contributed only slightly to the determination of storage root yield of CN 1108-13.

In order to confirm that sink capacity contributes to the determination of storage root yield, another grafting experiment of leaf-cuttings was conducted. Results in Table 3 generally support the findings in Table 2. When the low-yielding CN 1367-2 was used as scion and grafted on the high-yielding CN 1038-16, fresh storage root, total dry weight, and dry storage root/total dry weight were higher than those of the self-grafted CN 1367-2. Apparently, sink activity had a great influence in the determination of total dry weight, as well as storage root yield.

Table 3. Leaf area, fresh storage root weight, total dry weight, and harvest index (HI) of grafted leaf-cuttings.[z]

Grafting (scion/stock)	Leaf Area (cm^2)	Fresh Stge. Rt (g) per leaf-cutting	Total Dry Wt (g)	HI[y] (%)
1038-16/1038-16	142	19.4 ab	6.25 a	69 ab
1108-13/1108-13	159	9.5 cd	5.08 ab	53 bc
1367-2/1367-2	159	3.1 d	3.10 c	21 d
1108-13/1038-16	141	13.7 bc	5.51 a	53 bc
1367-2/1038-16	147	21.9 a	5.25 ab	77 a
1038-16/1108-13	146	5.7 c	4.09 bc	28 d
1038-16/1367-2	148	4.7 d	3.78 c	38 cd

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.
[y]HI = harvest index.

Conclusion

Results of these grafting experiments on leaf-cuttings showed that both source potential and sink capacity are important in determining the yield of sweet potato. However, the contribution of sink capacity seems to be significant. Results of this experiment indicate that the AVRDC high-yielding clone, CN 1028-15, had both good source potential and sink capacity; whereas CN 1367-2 showed both poor source potential and sink capacity. This may explain why yield potential differs among four clones tested under field conditions.

Although CN 1367-2 and CN 1028-15 had comparable leaf size, the former always contributed little to total dry matter yield when used as scion. It, therefore, seems unlikely that leaf size could determine the capacity of source potential. On the other hand, the sink capacity of high yielders, CN 1038-16 and CN 1028-15, seemed to overcome the poor source potential of CN 1367-2 and raised the latter's storage root yield.

These results suggest that genotypes with large source potential, sink capacity, or both should be the ones initially selected in breeding work and then subsequently improved by incorporating other desirable characteristics. The findings also indicate that the evaluation of source potential and sink capacity could be conducted by using leaf-cuttings as grafts, thus, making the evaluation of a large number of entries easier.

Growth and Nutrient Analyses of Sweet Potato Leaf-Cuttings

Introduction

Previous studies of rooted sweet potato leaf-cuttings reveal that the final storage root yield depends on the capacity of leaf-cuttings to translocate photosynthates from the leaf-blade (source) to the developing storage root (sink), and/or the capacity of the developing storage root to accommodate or receive photosynthates. Although the total dry matter yield of the leaf-cutting depends on the photosynthetic activity of the leaf-blade (source), the partition of dry matter may play an important role in the final determination of storage root yield.

The present study aimed to investigate the photosynthetic potential of leaf-blade through growth analysis to determine the nutrient content of the different parts, and to examine the relationship among potential photosynthesis, nutrient content, and final storage root yield.

Materials and Methods

Fully expanded leaves of similar blade size and petiole length positioned at the 4th to 7th node of CN 1028-15 and AIS 35-2, were cut at the base of the petiole and planted in polyethylene tubes (ID 10 cm, height 20 cm) filled with sand and soil at a 1:1 ratio. Leaf-cuttings were grown in the greenhouse and fertilized weekly with Hyponex No. 2 solution (20:20:20) at 1000 times dilution.

Leaf-cuttings were sampled at 1, 4, 7, and 10 weeks after planting. Sampled leaf-cuttings were measured for leaf area, petiole length, storage root yield, and fresh and dry weights of blade, petiole, adventitious root, and storage root of each leaf cutting. Each sample had three replicates, with four plants each. Dried tissues of the different parts of leaf-cuttings were analyzed for N, P, K, soluble sugar, and starch.

Results and Discussion

Table 4 shows that CN 1028-15 had higher storage root yield than AIS 35-2. However, total dry weight was not significantly different between the two clones. As discussed in the grafting experiment, yield difference was mainly due to the difference in dry matter partition. Potential photosynthesis as expressed in relative growth rate (RGR) was similar between two improved clones despite yield difference in storage roots (Table 5).

Nutrient analysis revealed that CN 1028-15 tended to accumulate more P, K, and soluble sugar in the leaf blade and petiole, less starch in the petiole, and more starch in the storage and adventitious roots than AIS 35-2 (Table 6).

Table 4. Growth and yield of leaf-cuttings from two sweet potato clones.[z]

Entry	Fresh Stge. Root (g)	Total Dry Wt (g)	Leaf Area (cm^2)	Petiole Dry Wt (g)	HI[y] (%)
		per leaf-cutting			
CN 1028-15	14.8*	5.79	312*	0.48**	48*
AIS 35-2	5.6	5.32	228	0.87	19

[z]Significant difference at the 5% (*), and 1% (**) level. [y]Harvest index.

Table 5. Relative growth rate (RGR) and growth rate (GR) of leaf-cuttings from two sweet potato clones.

Period[z]	RGR (mg/g/day)		GR (mg/day)	
	1028-15	35-2	1028-15	35-2
1 WAP - 4 WAP	91	93	101	113
4 WAP - 7 WAP	38	34	145	136

[z]WAP = weeks after planting.

Table 6. Nutrient contents (dry weight basis) in different parts of leaf-cuttings from two sweet potato clones at 10 weeks after planting.[z]

Entry	Blade	Petiole	Stge. Root	Advent. Root
Nitrogen (%)				
1028-15	4.0**	4.5	1.4#	2.9*
35-2	4.3	5.0	2.3	3.4
Phosphorus (mg/g)				
1028-15	14.2#	9.8	7.4	5.2
35-2	9.8	7.9	8.7	5.0
Potassium (mg/g)				
1028-15	34.2**	16.2	17.2#	27.1**
35-2	27.0	13.3	19.6	31.5
Sugar (mg/g)				
1028-15	60.1*	44.6**	159.6	55.1
35-2	39.6	33.3	155.3	45.4
Starch (mg/g)				
1028-15	26.5	84.8#	479.8*	58.4**
35-2	23.3	121.0	333.8	44.2

[z]Significant difference at the 10% (#), 5% (*), and 1% (**) levels.

We had specifically analyzed the nutrient content at the base of the petiole, where it may play an important role in controlling the flow of photosynthates between petiole and developing storage root. Data in Table 7 show that high-yielding CN 1028-15 accumulated more P, K, and soluble sugar than low-yielding AIS 35-2 at different growth stages of the leaf-cuttings. Interestingly, AIS 35-2 stored more starch at the petiole base. Since sucrose is a mobile form of carbohydrate in the plant and a major component of soluble sugar, high soluble sugar at the base of the petiole of CN 1028-15 may indicate that this sugar is readily translocated to the developing storage root.

Potassium is known to control translocation within the plant; therefore, a high level at the petiole base of CN 1028-15 supports the hypothesis about the importance of translocation/partition in determining high yield potential of sweet potato. Potassium and soluble sugar contents were also high in the leaf blade of CN 1028-15 (Table 8). Since soluble sugar is not readily translocated to the developing storage root of AIS 35-2, it may be converted to starch and accumulated in the basal part of the petiole (Table 7).

Table 7. Nutrient content (dry weight basis) at the base of the petiole of leaf-cuttings from two sweet potato clones.[z]

Stage	N (%)	P (mg/g)	K (mg/g)	Sugar (mg/g)	Starch (mg/g)
4 WAP					
1028-15	2.6*	17.2*	29.0*	84.0	69**
35-2	2.1	8.3	18.9	81.0	242
7 WAP					
1028-15	2.2	20.0*	20.7**	173*	25**
35-2	2.0	13.7	9.6	128	251
10 WAP					
1028-15	2.3**	20.6*	23.5**	183**	91*
35-2	3.1	12.0	16.2	104	195

[z]Significant difference at the 5% (*), and 1% (**) level.

Conclusion

Leaf-cuttings of both high-yielding CN 1028-15 and low-yielding AIS 35-2 produced equal amounts of total dry matter during the 10-week growing period. The yield difference was apparently due to the difference in the efficiency of translocating photosynthates to the developing storage root. The accumulation at the petiole base of high potassium and soluble sugar content in CN 1028-15 and high starch content in AIS 35-2 supports the hypothesis.

Table 8. Potassium and soluble sugar content (dry weight basis) in the leaf blade of leaf-cuttings from two sweet potato clones.[z]

Stage	Potassium (mg/g)	Soluble Sugar (mg/g)
1 WAP		
1028-15	21.1	40.2*
35-2	17.8	21.7
4 WAP		
1028-15	28.4*	54.1**
35-2	25.8	29.6
7 WAP		
1028-15	31.1#	56.7**
35-2	26.1	45.0
10 WAP		
1028-15	34.2**	60.1*
35-2	27.0	39.6

[z]Significant difference at the 10% (#), 5% (*), and 1% (**) levels.

Screening AVRDC Improved Sweet Potato Clones for Drought Tolerance

Introduction

Although sweet potato is relatively suitable for production in the marginal land, it can be severely limited by drought stress. Consequently, we initiated a survey of drought tolerance among our collection of improved sweet potato clones which have been meristem-cultured and preserved under *in vitro* conditions. This screening was based on the introduction of polyethylene glycol as an osmoticum and to create the low osmotic potential in the medium.

Materials and Methods

All 30 clones of improved and selected AVRDC materials presently kept in test tubes were tested twice in this survey. The plantlets were sectioned to single nodal cuttings and transferred and grown in test tubes with a fresh MS medium containing 1 ppm of NAA. Two weeks after initial culture, nodal cuttings were again transferred to a standard MS medium containing 1 ppm of NAA. The medium was further modified by adding polyethylene glycol-6000 (PEG) at 0, and 100 g/l.

Forty days after, the plantlets were investigated for plant height, leaf number, root length, and fresh weight. For every treatment, there were three replicates with four plantlets each. Since drought-tolerance screening was not initiated in the past, an AVRDC introduction reported to possess this characteristic from Taiwan, I 444 (Kimen), was used as reference.

Results and Discussion

Data based on plant height, leaf number, fresh weight, and root length showed that plantlet growth was noticeably restricted in the medium containing PEG at 100 g/l. On the average, more than 70% of height growth and 40% of fresh weight were affected by PEG. Among 30 clones, both I 444 and CN 1038-16 were least affected by PEG. Thus, it appears that the desired drought- tolerant characteristic of I 444 can also be detected by *in vitro* testing with PEG.

Conclusion

The AVRDC tissue-cultured collection of improved and selected sweet potato clones was evaluated for drought tolerance by introducing PEG to the medium. This technique identified CN 1038-16 as having drought tolerance comparable to accession I 444. The tolerance levels of these clones will be confirmed next year.

In Vitro Storage-Root Formation of Sweet Potato

Introduction

To expedite the international distribution of disease-tested sweet potatoes, AVRDC uses both tissue-cultured materials that are multiplied and maintained in test tubes, and small storage roots obtained from leaf-cuttings taken from meristem-tip-derived plants which have been cultivated in vermiculite and maintained in an insect-free screenhouse. However, both methods have their drawbacks. Sweet potato materials transported in test tubes may suffer from exposure to extreme temperatures, rough handling, or difficulty in regeneration due to lack of capable personnel or facilities. As for the small storage roots, they may still be reinfected, although they are grown in the screenhouse.

The present study investigated the possibility of obtaining small storage roots under *in vitro* conditions. This method eliminates the drawbacks of shipping materials in test tubes or in small storage roots.

Materials and Methods

Leaves with petioles were excised from plantlets of AIS 35-2 derived from the meristem-tip culture under *in vitro* conditions. These were grown in 20 ml of modified MS medium containing 3948 mg/l of KNO_3, 8% of sucrose but without agar and NH_4NO_3, and at 1.8 g/tube of perlite. The modified MS medium was added with NAA, BA, kinetin, and GA_3 at 0.5 mg/l and 5.0 mg/l in different combinations. Large test tubes (12 × 3 cm) with bottoms covered by tinfoil were used. There were 10 treatments, each having 10 to 15 test tubes.

Results and Discussion

Although there is the possibility of white potato tuberization on agar through the manipulation of the auxin- cytokinin ratio, unfortunately this situation did not occur with sweet potato. Tuberization in white potato is the formation of thickened structures which are technically modified stems, and usually takes place on the surface of agar under *in vitro* conditions. In sweet potato storage roots, on the other hand, thickening occurs on adventitious roots formed on the nodes. As far as we know, there is no report on the storage root formation of any crop under *in vitro* conditions.

According to sweet potato physiology, storage root formation depends on the availability of oxygen and on sink strength of the adventitious roots destined to be storage roots. Subsequent attempts on *in vitro* storage-root formation of sweet potato involved the use of leaf cuttings from the plantlets instead of whole plantlets, in order to encourage translocation of dry matter to the developing adventitious root; and the replacement of agar by perlite to encourage aeration in the root system. The MS medium was also modified to increase potassium concentration, and added with different combinations of NAA, BA, kinetin, ABA, and GA_3.

The combination of NAA at 0.5 mg/l and GA_3 at 5.0 mg/l in the modified MS medium did induce storage root formation after 110 days of *in vitro* culturing. The rate of storage formation was about 30%. Presently, further work is still in progress to enhance the chance of storage root formation through the inducement of air exchange, increase of bulk density in the medium, etc. We feel that storage root produced directly under *in vitro* conditions should be better suited to international distribution of the AVRDC elite breeding lines.

Conclusion

Formation of small storage roots was induced under *in vitro* conditions. About 30% leaf-cuttings of AIS 35-2 formed storage root when cultured in a modified MS medium with NAA 0.5 mg/l, GA_3 5.0 mg/l, 37.6 mM of potassium, 8% sucrose, and perlite as the supporting medium. Work is still in progress to increase the percentage of storage root formation under *in vitro* conditions. As far as we know, this study is the first investigation that induced storage root formation of sweet potato under *in vitro* conditions.

Tomato Breeding

Crosses and Segregating Populations

In 1985, we accorded high priority to the incorporation of resistance to common root-knot nematode and bacterial leafspot to advanced tropical breeding lines (Table 1). Furthermore, we chose only sources of nematode resistance that bear firm and medium to large fruits. For bacterial leafspot resistance, we continued to use Hawaii 7998 as resistant parent. However, the tropical stocks were only those with good levels of heat and bacterial wilt resistance, carry the Tm2a gene for tomato mosaic virus resistance, and bear some fruit firmness.

Table 1. Type of crosses made in 1985 in the tropical tomato program.

Characters of Donor Parents[z]	Tropical Parent Stocks[z]							No.
	HT	BWR	Tm2a	Firm	HT	BWR	Tm2a	Crosses
Mi, Tm2a, large fruit, firm fruits			7			3		67
Mi, large fruit, firm fruits			3			2		23
BLS resistant, some resistance to wilt, medium fruit size			4			–		4
Others[y]			10			5		43
Total								137

[z]HT = heat tolerant; BWR = bacterial wilt resistant; Tm2a = dominant gene for tomato mosaic virus resistance; Mi = dominant gene for rootknot nematode resistance; BLS = bacterial leafspot. [y]Include stocks carrying PVY resistance, alcobaca, dark green fruit color.

Apart from the tropical tomato crosses, we also made 166 new hybrid combinations in the processing tomato program (Table 2). The general objective in most of these crosses was to develop hybrid cultivars with heat and bacterial wilt resistance, resistance to mosaic virus and root-knot nematode, and improved fruit firmness and size. As several of these desirable characters are already in the advanced tropical lines, the involvement of such stocks in the processing-type crosses has become considerable. The sources of nematode resistance were introduced temperate-bred processing cultivars with good firmness.

The first batch of segregating backcross families from crosses to develop nematode-resistant tropical tomato became available for selection in 1985. As the electrophoresis method was not yet operational, these families were screened for nematode resistance in the BC1F2 generation by the egg-inoculation method. The resistant plants from these families were advanced to BC1F3 generation and subsequently screened by electrophoresis to select homozygous (Mi/Mi) lines.

Further selection for good horticultural characters among plants within the homozygous lines was carried out and the plants advanced to BC1F4 generation. Most of the promising BC1F4 lines were evaluated for heat tolerance in summer 1985, and individual plants were selected from the best lines.

Tables 3 and 4 summarize the segregation for nematode resistance of several BC1F2 families screened by the egg-inoculation method and subsequent descendants screened for homozygosity of resistance by electrophoresis. Not all BC1F2 families could be screened by electrophoresis in the BC1F3 generation because the linkage of Mi gene with Aps-1 (acid phosphatase isozyme) locus in the nematode-resistant parents has been reportedly broken.

Table 2. Type of crosses made in 1985 in the processing tomato program.

Characters of Donor Parents[z]	Tropical Parent Stocks[z]						No.
	HT	BWR	Tm2a	Firm	HT	BWR	Tm2a	Crosses
Mi, firm fruits			10			2		42
Tm2a, firm fruits						2		12
Firm, medium-large fruits			10			2		72
Moderately firm, large fruits			8			2		40
Total								166

[z]HT = heat tolerant, BWR = bacterial wilt resistant, Tm2a = dominant gene for tomato mosaic virus resistance, Mi = dominant gene for root knot nematode resistance

Table 3. Segregation for nematode resistance among BC1F2 populations screened by the egg-inoculation method, AVRDC 1985.

Family	Total Sample	Expected Proportion[z]		Observed Proportion[z]		X^2	Probability
		R	S	R	S		
CLN 305	1079	809	270	704	375	55.3	< 0.005
CLN 308	1131	848	283	656	475	175.2	< 0.005
CLN 337	1122	841	281	736	386	53.4	< 0.005
CLN 346	965	724	241	727	238	< 1	> 0.250
CLN 363	1151	863	288	873	278	< 1	> 0.250

[z]Based on theoretical expected ratio of 3 resistant : 1 susceptible

Table 4. Segregation for homozygosity of nematode resistance among BC1F3 lines screened by electrophoresis, AVRDC 1985.

Family	Total Sample	Expected Proportion[z]			Observed Proportion[z]			X^2[y]	Probability
		Mi/Mi	Mi/+	+/+	Mi/Mi	Mi/+	+/+		
CLN 308	408	136	272	0	82	305	21	25.7	< 0.005
CLN 337	319	103	207	0	50	254	6	64.2	< 0.005
CLN 346	238	79	157	0	88	148	2	1.5	.10 - .25

[z]Based on theoretical expected ratio of 1 Mi/Mi : 2 Mi/+ : both resistant, +/+ = susceptible
[y]Excludes the unexpected +/+ lines.

This was also confirmed at AVRDC on parental stocks screened by electrophoresis and egg-inoculation prior to crossing. In three BC1F2 families (Table 3), there was clearly a gross underestimation of the resistant class. Good fit was obtained only in families CLN 346 and CLN 363.

Of the BC1F3 families screened by electrophoresis, only CLN 346 showed good fit to the expected ratio (Table 4). This is one of two families that showed a normal segregation pattern in the previous BC1F2 generation. The high proportion of theoretically unexpected susceptible (+/+) plants detected in family CLN 308 indicate that susceptible plants were misclassified as resistant in the previous generation screened by egg inoculation. These +/+ plants were also detected in the other families although at much lower proportions. From the present set of materials, it is difficult to decide which of the two methods is more accurate. Theoretically, the latter is expected to be more precise, as it is not greatly influenced by environmental vagaries.

In another set of 29 segregating double cross families screened by electrophoresis, good fit was obtained from 22 families. Of the seven that showed abnormal ratios, three had very small sample sizes and four invariably showed the absence of homozyous resistant plants expected in 1/4 proportion of the progenies. In these four families, two possibilities exist: original resistant stocks may actually have been susceptible or linkage of Mi gene with Aps-1 locus may already have been broken but not reported. We will closely monitor the original parents of these crosses to determine the probable cause of the unexpected segregation ratios.

On a routine basis, other types of segregating populations were also handled by the program in 1985. Most of these were advanced selections from the last batch of crosses aimed to incorporate tomato mosaic virus resistance and other desirable characters, such as improved fruit size and firmness, to tropical tomato.

Evaluation of New Tropical Breeding Lines for Bacterial Wilt Resistance

Introduction

Bacterial wilt (*Pseudomonas solanacearum*) is the most devastating disease of tomato in the hot, humid tropics. New lines in the tropical tomato improvement program must, therefore, hold a good level of resistance to this disease while additional components of tropical adaptation are continually added.

In 1985, breeders and pathologists screened new tropical breeding lines for bacterial wilt resistance. These lines have been previously selected for heat tolerance, resistance to tomato mosaic virus, and good horticultural characteristics, such as improved size, firmness, and crack resistance.

Materials and Methods

Two sets of replicated trials were conducted. The first set consisted of 46 entries including the standard susceptible and resistant checks, L 390 and L 285, respectively. The second set was made up of 38 entries. The design in both tests was randomized complete block with two replications. Each plot consisted of one row, 8 m long. Spacing between rows was 100 cm and between hills, 40 cm. The first trial was sown on 13 June, 1985; and seedlings were transplanted on 15 July, 1985. The second trial was sown on 13 June and transplanted to the bacterial wilt nursery on 16 July.

This nursery was prepared by raising a previous crop of susceptible L 390 tomatoes which were clip-inoculated with the bacterial wilt pathogen six weeks after transplanting. When infection rate was nearly 100%, the field was rototilled and prepared for transplanting of the test entries. Wilt infection was recorded at different dates (from 29 July to 13 September, 1985, ten times at 3-day intervals), and final infection percentage was determined for each entry.

Results and Discussion

Eight lines in the first trial and 14 in the second trial had wilt infection equal to or less than that of the highly resistant check, L 285. In general, however, the overall wilt infection percentage was low especially in the second trial. Even the standard susceptible check, L 390, showed only 17% infection. The high coefficient of variability in both trials also attested to the heterogeneity of the inoculum potential in the nursery. In view of these difficulties, only the most susceptible lines were discarded from both trials. The remaining lines will be re-evaluated in the 1986 summer season possibly reverting back to the seedling screening method and/or a modified field technique in which the inoculum density is maintained more uniformly than in the present method.

Conclusion

The present field screening technique was found to be inadequate to achieve an accurate selection for bacterial wilt resistance. The problems of heterogeneity in the inoculum density and low infection rates among entries, as well as in the susceptible check, need to be resolved before any field screening method can be fully adopted.

In the present experiments, only the highly susceptible lines were discarded. The remaining lines will be re-evaluated in 1986 either with the seedling screening method previously used by the program or with a modified field screening technique that is proven to be suitable.

Evaluation of New Germplasm for Heat Tolerance

Introduction

As part of a collaborative project, we received from Campbell Soup Company 12 new breeding stocks which were derived from their recurrent selection program for heat tolerance. These materials were evaluated during the 1985 hot season at AVRDC under two conditions: in the shade house and open field.

Materials and Methods

The new lines were sown on 7 May 1985. Included as check entries were CL 1131-13-0-6 and CL 5915-153-3-3, both heat-tolerant tropical lines, and TK 70, heat-sensitive variety. Ten seedlings of each entry were transplanted into 12-inch pots on 2 June, 1985 and arranged subsequently in a randomized complete block design, with two replications, having five pots each, and grown under a plastic shade house. Light intensity in the shade house was 35%, 70%, and 52% of the normal open conditions in the morning (9:50), noon (12:50), and afternoon (4:20), respectively. Data on fruit-set, yield, and other horticultural characters were recorded.

A separate experiment was set up to evaluate the new germplasm under field conditions. For this experiment, 24 seedlings of each entry were transplanted to the field on 9 August 1985 in a randomized complete block design, with two replications, having 12 plants each. Each plot consisted of one row, 4.8 m long, with rows 150 cm apart and plants within row, 40 cm apart. Data on fruit set, yield, and other horticultural characters were taken.

Results and Discussion

None of the new germplasm compared favorably in heat tolerance to the tropical breeding lines (Tables 5 and 6). Under shade house conditions, the best line was M 6037-2 which outperformed the heat-sensitive check, TK 70, but was conspicuously inferior to the heat-tolerant checks. In this trial, the heat-tolerant checks showed more inserted stigmas and reduced level of antheridial cone-splitting (ACS) than the heat-sensitive TK 70. M 6037-2 also had inserted stigmas but showed a relatively higher ACS level than either heat tolerant check.

Under field conditions, line CX 8207 performed better than M 6037-2 and had comparable yield and fruit-set as the heat-tolerant checks. Although its fruit load is only about 50% of CL 5915-153-3-3, total yields are similar because fruit size of CX 8207 is twice as big as that of the latter. The relatively poor performance of heat tolerant CL 1131-13-0-6 in the field was due mainly to severe bacterial leafspot infection.

Conclusion

Twelve new lines which originated from the recurrent selection program for heat tolerance of Campbell Soup Company were evaluated for fruit-setting ability during the 1985 summer season under shade house and field conditions. None of the new lines performed as well as the tropical lines CL 1131-13-0-6 and CL 5915-153-3-3. One entry, M 6037-2, did better than TK 70, the heat-sensitive check. In the field, CX 8207 compared favorably with CL 5915-153-3-3 in overall performance. However, the field test was severely infected by bacterial leafspot which influenced the outcome of the trial.

From this preliminary evaluation, it appears that heat tolerant genotypes selected under the hot, dry conditions of California may not necessarily perform as well as tropical lines selected under hot, humid conditions. However, they are relatively better adapted to high temperatures than the traditional cool-season cultivars.

Table 5. Performance of the best new germplasm compared to checks under shade house conditions, AVRDC, summer 1985.

Entry	Fruit-Set (%)	Days to Flowering	Stigma Exsertion[z]	Antheridial Cone Splitting[y]	Yield Per Plant (g) total	Yield Per Plant (g) marketable	Harvest Index (%)	Fruit Load (no./plant)	Fruit Size (g)
M 6037-2	45.6 bc	22 a	2.7 ab	4.2 b-d	769 c	511 bc	54 bc	18 bc	29 bc
CL 1131-13-0-6 (HT check)	77.6 a	16 b	3.0 a	2.6 fg	1101 a	1018 a	76 a	55 a	21 cd
CL 5915-153-3-3 (HT check)	66.8 ab	22 a	2.8 ab	2.5 g	1074 ab	983 a	76 a	47 b	19 d
TK 70 (HS check)	21.5 d	20 a	1.0 d	5.9 a	408 e	353 c	36 c	10 e	36 ab
Grand Mean (15 entries)	36.3	21	2.4	3.7	505	694	53	27	25
CV (%)	15.6	7	12.6	13.1	19	13	8	22	14

[z]Rated on 1-5 scale: 1 = stigma exserted, 5 = stigma inserted. [y]Rated on 1-9 scale: 1 = cone intact; 9 = severe splitting.

Table 6. Performance of new germplasm under field conditions, AVRDC, summer 1985.

Entry	Total Yield (g/plt)	Fruit Set (%)	Fruit Size (g)	Fruit Load (no./plt)	Bacterial Leaf-spot Rating[z]
CX 8207	815 a	29.8 a-c	41 a-c	20 bc	6.5
M 6037-2	360 b-d	25.9 a-d	33 b-e	12 cd	6.0
CL 5915-153-3-3 (HT check)	840 a	46.0 a	19 e	46 a	6.0
CL 1131-13-0-6 (HT check)	585 ab	34.4 ab	23 de	26 b	8.0
TK 70 (HS check)	345 b-d	10.7 d	58 a	7 d	6.5
Grand Mean	357	24.0	33	13	6.9
CV (%)	32	18.9	23	42	15.2

[z]Based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation).

Performance of New Breeding Lines

Introduction

In 1984, we reported that resistance to tomato mosaic virus (ToMV) had been successfully incorporated into tropical lines. We continued to select new materials from other crosses in the 1985 ToMV resistance project. These new selections were entered in the 1985 observational trial and/or preliminary trial. In addition, the best lines from the 1984 preliminary trials were carried into the 1985 advanced yield trials (AYT), along with other entries selected from the 1984 AYT.

We also reported in 1984 that both additive and nonadditive gene actions control the expression of heat tolerance based on the results of diallel crossing experiments. In 1985, we reexamined this subject using advanced heat tolerant selections and commercial cultivars as parental stocks in an F1 hybrid breeding scheme. We also continued the search for processing tomato hybrids with acceptable levels of heat tolerance and disease resistance.

Materials and Methods

F1 hybrids vs. parental stocks. Thirty-three F1 hybrid combinations were made advanced tropical breeding lines and commercial fresh market cultivars which are traditionally grown only in the cool season. As the number of entries was large, the materials were divided into two trials. The first trial was sown on 15 June and transplanted to the field on 16 July for evaluation of heat tolerance and other characteristics during the hot season. The second trial was sown on 10 June and transplanted on 16 July. Respective parents of each hybrid were included as test entries along with check cultivars, TSS No 1 (only in Trial I) and KingKong, both purportedly heat tolerant F1 hybrids.

The design was randomized complete block with two replications. Each replicate consisted of a single two-row bed, 4.8 m long, with rows 0.[illegible] m apart within the bed and plants 40 cm apart within the row. All entries, except the determinate parents, were staked and pruned to maintain only seven fruiting clusters in a two-branch pruning scheme. Data on yield and other horticultural characters were taken.

Observational trial. Thirty selections were entered in the observational trial and compared with tropical lines CL 1131-13-0-6 and CL 9915-93-1-0. Seeds were sown on 4 June and transplanted on 12 July in a randomized complete block design with two replications. Each plot consisted of a single row, 4.8 m long, with rows 150 cm apart within bed, and plants 40 cm apart within the row. Yield and other horticultural characters were recorded.

Preliminary trial. Twenty-one selections were compared with tropical line CL 1131-13-0-6 in the preliminary trial. This trial (PYT I) was sown on 4 June and transplanted on 12 July in a randomized complete block design with two replicates. Each plot consisted of a single row, 4.8 m long, with rows 150 cm apart and plants within the row 40 cm apart. Yield and other horticultural characters were recorded. Because of normally severe infection by bacterial leafspot, a duplicate set of this trial was planted. This set (PYT II) was sown on 21 June and transplanted on 19 July. Experimental design and management practices were similar to the first trial (PYT I).

Advanced yield trials. Four sets of advanced trials, each consisting of 40 entries including the tropical line CL 1131-13-0-6 as check, were planted in summer 1985. Most of these lines were selected from the 1984 preliminary and advanced yield tests and all carry resistance to ToMV. Each trial used a randomized complete block design with three replications. A plot consisted of four rows, each 4.8 m long, with rows spaced 150 cm apart, and plants within the row, 40 cm apart. Sowing and transplanting dates of each trial are as follows:

	Sown	Transplanted
Trial I	30 April	30 May
Trial II	21 May	21 June
Trial III	10 June	12 July
Trial IV	13 June	17 July

Yield and other important horticultural characters were recorded. Combined data analyses for horticultural attributes such as yield and fruit-setting ability were carried out to determine the response of each genotype to a limited set of environmental alternatives in the 1985 summer season.

Processing tomato hybrids. Eight processing tomato hybrids were compared with check cultivars, TK 70 and Tainan No. 2, in a trial planted about a month earlier than the normal planting time for commercial processing tomato in Taiwan. The experimental design was randomized complete block with three replications. Each plot consisted of four rows, each 4.8 m long, with rows 150 cm apart and plants within row, 40 cm apart. Sowing and transplanting dates were 11 July and 9 August, respectively. Yield and other horticultural characters were recorded.

Results and Discussion

F1 hybrids vs. parental stocks. Three combinations between tropical lines and heat-sensitive fresh-market cultivars (L 4783 and L 203) in Trial I performed better than commercial checks TSS No. 1 and KingKong (Table 7). However, the marketable yields of these hybrids were not statistically different from that of the best heat tolerant parent stock, CL 5915 206-2-5, partly because of high culling rate especially in the cross CL 5915 206-2 × L 4783 Sel 1. Although not statistically significant, the new hybrids also tended to produce larger fruits than parent stock CL 5915 206-2-5 and check cultivars. Other striking advantages of the hybrids were fruit firmness, crack resistance, and lower levels of bacterial leafspot infection.

In Trial II, comprised largely of combinations among heat tolerant lines, several hybrids outperformed the heat tolerant parental stocks, as well as the commercial check cultivar, KingKong (Table 8). However, except for crosses with BL 181 and BL 182, both of which are heat-sensitive fresh-market cultivars, the hybrids tended to produce small fruits although still comparable to that of KingKong. Again, some of the desirable attributes of these hybrids were resistance to cracking and better fruit firmness. Some also showed relatively lower bacterial leafspot infection.

Fig. 1 shows the trends for different horticultural characters of crosses with various heat-tolerant levels in their parentage. Although only a simple trend analysis, it is clear that heat tolerant (HT) x heat tolerant (HT) crosses had the best overall performance during the hot season. In general, this type of cross had high fruit-setting ability which was ultimately translated into high total and marketable yields. Because heat tolerant stocks bear relatively small fruits, the HT/HT crosses produced smaller fruits than the HT/HS crosses.

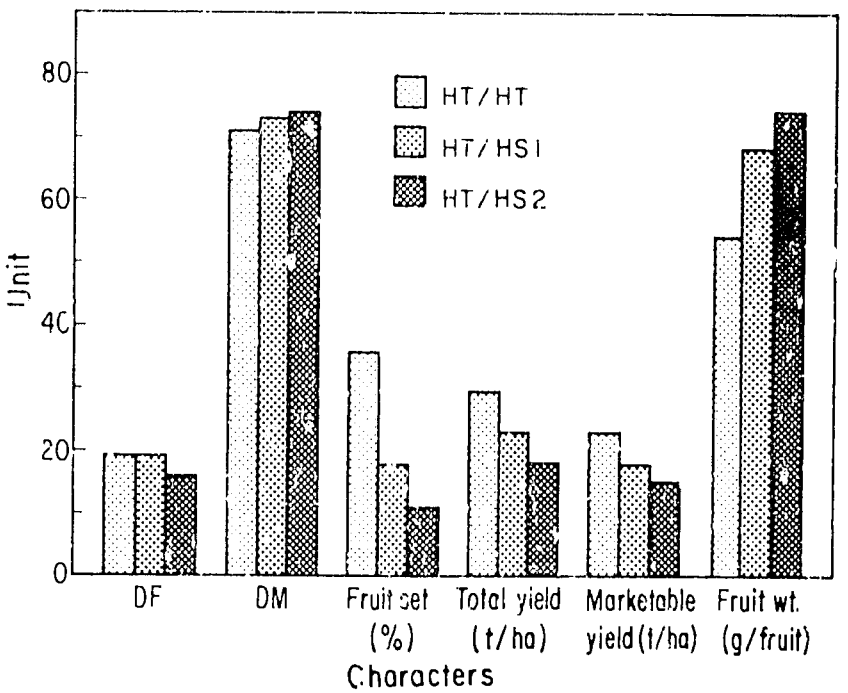

Fig. 1. Trends of different characters in F1 hybrids with various levels of heat tolerance.

Table 7. Best performing fresh-market hybrids and parent stock (Trial I) compared with check cultivars, AVRDC, summer 1985.

Entry	Yield (t/ha)		Days to		Fruit-Set	BLS Rating[z]	Fruit Size	Cracking[y]	Relative
	Total	marketable	flowering	maturity	(%)		(g/ft)		Firmness[x]
CL 5915-206-2-4/L 4783 sel (1)	28.8 a	22.2 a	20	74	31.8 a	6.5 b-e	76 a-c	slight S	MF
CL 5915-206-2-4/L 4783 sel (2)	27.6 ab	22.2 a	18	72	22.1 a-d	5.0 d-h	69 a-d	very slight R	F
CL 5915-206-2-5/L 203	23.4 a-c	19.2 ab	18	72	20.9 a-e	6.5 b-e	83 ab	none	F
CL 5915-206-2-5 (P)	20.1 b-d	18.2 ab	18	72	17.2 b-f	5.5 d-h	54 b-e	none	F
TSS No. 1 (check)	9.7 e-i	6.0 h-k	18	72	25.4 ab	8.0 ab	69 a-d	severe C	S
KingKong F1 (check)	12.4 d-h	9.6 f-g	20	74	20.7 a-e	8.0 ab	63 a-d	severe R/C	S
Grand Mean	12.8	10.6	18	69	12.5	6.5	59	–	–
CV (%)	27.6	24.8	7	2	17.7	12.7	21		

[z]BLS = bacterial leafspot; based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation). [y]S = superficial; R = radial; C = concentric. [x]F = firm; MF = moderately firm; S = soft.

Table 8. Best performing fresh-market hybrids (Trial II) compared with a check cultivar, AVRDC, summer 1985.

Entry	Yield (t/ha)		Days to		Fruit Set	BLS Rating[z]	Fruit Size	Cracking[y]	Relative
	total	marketable	flowering	maturity	(%)		(g/ft)		Firmness[x]
CLN 95-244-1-0/CLN 91-392-1-1	36.8 a	29.0 a	20 a-c	71 gh	35.7 a-c	3.0 de	55 m-o	none	MF
CLN 95-244-1-0/CL 5915-206-2-2	37.5 a	28.5 ab	21 a-c	71 gh	32.0 a-c	4.0 c-e	60 j-m	none	F
CL 5915-39-1-2/BL 181	32.6 ab	27.6 a-c	14 d-g	70 gh	27.0 a-d	6.5 a-c	86 b	slight R	F
CLN 95-244-1-0/CL 5915-93-1-0	33.2 ab	26.0 a-d	16 b-f	71 gh	37.9 a-c	4.0 c-e	59 k-n	none	MF
CL 5915-39-1-2/BL 182	33.2 ab	25.5 a-d	13 fg	70 gh	35.3 a-c	6.5 a-c	81 cd	none	F
KingKong F1 (check)	16.5 gh	13.2 h-j	21 ab	77 b-f	19.3 b-d	5.0 b-e	58 k-o	severe R/C	S
Grand Mean	18.6	15.3	18	74	18.8	5.6	57	–	–
CV (%)	16.7	17.6	11	3	23.5	21.1	4	–	–

[z]BLS = bacterial leafspot; based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation). [y]S = superficial; R = radial; C = concentric. [x]F = firm; MF = moderately firm; S = soft.

The next best combination was HT/HS1, where HS1 were stocks with some degree of fruit-setting ability in the hot season. Since these HS parents generally had large fruits, the average fruit weights of F1's of this type of cross were higher than those of HT/HT crosses.

The most inferior combinations were of the HT/HS2 type where the latter is completely heat-sensitive (no fruit-set). However, these combinations produced the largest fruits among the different cross types. Exceptional crosses within the HT/HS1 and HT/HS2 groups showed good fruit-setting and yielding ability that were comparable to the best combinations in the HT/HT class. These exceptional crosses become evident when the range of values for traits, such as fruit set and yield, are examined. Thus, improved performance of F1 hybrids does not appear to be an exclusive property of the HT/HT type.

When the F1 means were compared to the theoretical midparent means and examined for gene action trend, a great proportion of the crosses approximated the dominance to overdominance range. In particular, F1's from the HT/HT type of crosses clearly outperformed their best parents for fruit set ability and yield, except in one cross. In the HT/HS1 type, overdominance was much less preponderant; but generally, all F1 performances fell within the dominance to overdominance range. No dominance gene-action type appeared in the HT/HS2 type. However, in one group of crosses, the F1's performed better than the heat tolerant parent.

The results corroborate our previous findings that both additive and nonadditive types of gene action underlie the expression of heat tolerance in tomato.

Observational trial. Three new lines outperformed both check lines, CL 1131-13-0-6 and CL 5915-93-1-0, in this trial which was severely infected by bacterial leafspot (Table 9). The most promising of these new lines are CLN 65-349D5-2-1-0 and its sister line, CLN 65-349D5-2-2-0, both of which showed lower bacterial leafspot damage, and bore fruits which were firm, crack-resistant, and of improved size. One other line, CLN 95-280D5-6-0, showed good fruit-setting ability and larger fruits than other entries but was extremely susceptible to bacterial leafspot. Fruits of this line were also soft.

Preliminary trial. In general, none of the new lines outperformed the tropical line, CL 1131-13-0-6, in PYT-I (Table 10). Except CLN 91-392D5-1-0-0 and CLN 95-280D5-1-0-0, the new lines tended to have lower fruit set than CL 1131-13-0-6. However, their low fruit-set rates were compensated by their larger fruit sizes, thus putting their overall productivity approximately at par with the check line. Apart from improved fruit size, all new lines, except CLN 95-280D5-1-0-0, had significantly lower bacterial leafspot damage.

The duplicate trial (PYT-II) was also heavily infected with bacterial leafspot (Table 11). The superiority of the new lines (except CLN 95-280D5-1-0-0) over CL 1131-13-0-6 in terms of lower bacterial leafspot infection rate was again evident, however. Although CL 1131-13-0-6 had higher fruit-setting rate than the new lines, the overall productivity of the latter was generally better partly because of greatly improved fruit size (about twice that of CL 1131-13-0-6) and lower damage due to bacterial leafspot. New lines from the CLN 65 series also demonstrated their superiority over other entries in fruit characteristics, such as firmness and absence of cracking.

Advanced yield trials. Table 12 shows the average performance of entries which outyielded the tropical check line, CL 1131-13-0-6. Based on yield, fruit characteristics, and bacterial leafspot infection, the best of the advanced lines were CL 5915-93-1-0, CL 5915-223-2-1-0, and CLN 65-349-2-0. These lines showed better than average yields, and fruits of improved size with very slight or no cracking and moderately firm to firm feel. In addition, these lines showed lower bacterial leafspot infection than other entries.

Although fruit-setting of check CL 1131-13-0-6 was relatively higher than that of the above entries, it had lower overall productivity because of small fruit size and high susceptibility to bacterial leafspot. Moreover, its fruits were soft and exhibited severe concentric and radial cracking problems. Among the test entries, CL 5915-153-3-3 had the best fruit-setting ability and better fruit size and firmness than CL 1131-13-0-6. However, it showed severe concentric cracking and bacterial leafspot infection.

From combined data analyses and on the basis of stability of performance, the best line among the three mentioned above was CLN 65-349-2-0 (Fig. 2). In this graphical interpretation, a good, stable cultivar is defined as one with a regression coefficient not statistically different from unity (1),

Table 9. Yield and other horticultural characteristics of new lines in the observational trial, AVRDC, summer 1985.

Entry	Yield (t/ha)		Days to		Fruit-Set	Fruit Size	BLS Rating[z]	Cracking[y]	Relative Firmness
	total	marketable	flowering	maturity	(%)	(g/ft)			
CLN 95-280D5-6-0	23.1 a	18.7 ab	16 fg	73 d-f	32.3 a-c	49.6 a-c	9.0 a	VSR	soft
CLN 65-349D5-2-1-0	22.3 a	20.3 a	20 a-c	76 b-d	25.2 a-d	42.8 b-g	4.5 f	none	firm
CLN 65-349D5-2-2-0	20.7 ab	19.8 a	20 a-e	78 a-c	22.8 a-d	39.6 b-g	6.0 c-f	none	firm
CL 1131-13-0-6 (HT check)	13.8 c-g	10.6 c-g	14 g	73 d-f	28.2 a-d	25.4 h-k	8.5 ab	C/R	soft
CL 5915-93-1-0 (HT check)	12.2 c-g	10.7 c-g	17 e-g	76 b-d	15.8 c-e	39.1 b-g	6.0 c-f	none	moderate
Grand Mean	13.1	10.6	18	75	22.7	38.7	7.2	–	–
CV (%)	21.4	25.4	8	2	17.4	14.4	12.7	–	–

[z]BLS = bacterial leafspot; based on 1-9 scale: 1 = no symptom; 9 = very severe (massive defoliation). [y]VSR = very slight radial cracking; CR = both radial and concentric cracking present.

Table 1C. Yield and other norticultural characters of selected entries in the preliminary yield trial (PYT I), AVRDC, summer 1985.

Entry	Yield (t/ha)		Days to		Fruit Set	Fruit Size	BLS Rating[z]
	total	marketable	flowering	maturity	(%)	(g/ft)	
CLN 65-349D5-1-0-0	17.9	16.1	18 c	75 ab	20.6 c-d	43.6 cd	5.5 d-g
CLN 65-349D5-2-0-0	16.8	15.7	18 c	77 a	20.2 c-d	42.7 c-e	3.5 h
CLN 91-139D5-1-0-0	16.0	13.7	24 ab	80 a	14.1 d	43.4 cd	3.5 h
CLN 91-392D5-1-0-0	13.5	12.1	24 ab	78 a	27.6 a-d	50.3 c	4.5 f-h
CLN 95-280D5-1-0-0	16.9	13.6	12 d	71 ab	28.1 a-d	50.4 c	9.0 a
CL 1131-13-0-6 (HT check)	18.6	15.4	12 d	68 b	37.6 ab	30.0 g	8.5 ab
Grand Mean	12.8	11.1	17	76	27.0	40.4	5.8
CV (%)	27.5	30.0	12	9	14.0	9.6	13.1

[z]BLS = bacterial leafspot; based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation.)

Table 11. Yield and other horticultural characters of selected entries in the preliminary yield trial (PYT II), AVRDC, summer 1985.

Entry	Yield (t/ha) total	Yield (t/ha) marketable	Days to flowering	Days to maturity	Fruit-Set (%)	Fruit Size (g/ft)	BLS Rating[z]	Cracking[y]	Relative Firmness
CLN 65-349D5-1-0-0	16.1 a-e	15.0 a-g	18 b	74 a	29.8 d-h	46 a-d	6.0 bc	none	firm
CLN 65-349D5-2-0-0	18.8 a-d	17.9 a-e	18 b	74 a	36.1 c-g	48 e-g	4.0 e-g	none	firm
CLN 91-139D5-1-0-0	21.8 a	21.0 a	20 a	74 a	26.1 gh	46 a-d	3.0 g	R/C	soft
CLN 91-392D5-1-0-0	21.1 ab	19.8 ab	20 a	74 a	30.4 d-h	56 a	3.0 g	R	soft
CLN 95-280D5-1-0-0	14.6 b-f	11.8 e-g	18 b	69 c	39.8 b-e	54 a	8.5 a	VSR	soft
CL 1131-13-0-6 (HT check)	13.4 d-f	11.8 e-g	14 c	70 bc	53.5 a	25 h	8.5 a	SC	soft
Grand Mean	15.3	14.1	18	73	34.8	43	5.6	–	–
CV (%)	17.9	19.0	5	2	7.6	10	9.4	–	–

[z]BLS = bacterial leafspot, based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation). [y]R/C = both radial and concentric cracking present; VSR = very slight radial cracking; R = only radial cracking present; SC = slight concentric cracking.

Table 12. Average performance of the best entries in four advanced yield trial sets, AVRDC, summer 1985.

Entry	Yield (t/ha) total	Yield (t/ha) marketable	Yield (t/ha) cull	Fruit Set (%)	Maturity (days)	Fruit Load (no./plant)	Fruit Size (g)	Cracking[z]	Relative Firmness[y]	BLS Rating[x]
CL 5915-93-1-0	32.2	29.4	2.8	29.8	73	76	60	very slight R/C	MF-F	6.2
CL 5915-153-3-3-0	29.7	27.4	2.2	38.5	75	104	42	severe C	MF	7.3
CL 5915-223-2-1-0	26.4	25.4	1.0	24.4	76	71	56	none	MF-F	4.3
CL 1131-26-1-0-1-0	33.2	30.1	3.1	33.6	74	195	26	slight C/R	S	6.2
CLN 65-349-2-0	28.6	27.2	1.4	26.7	75	63	57	none	F-VF	4.8
CL 1131-13-0-6 (check)	25.4	22.9	2.4	34.8	71	79	33	severe C/R	S	8.2
Grand Mean	26.8	24.7	2.0	30.0	73	102	40	–	–	–

[z]BLS = bacterial leafspot; data taken from three of four trials; R = radial cracking; C = concentric cracking. [y]Data taken from three of four trials; MF = moderately firm; F = firm; VF = very firm; S = soft. [x]Data taken from two trials; based on 1-9 rating scale: 1 = no symptom; 9 = very severe (massive defoliation).

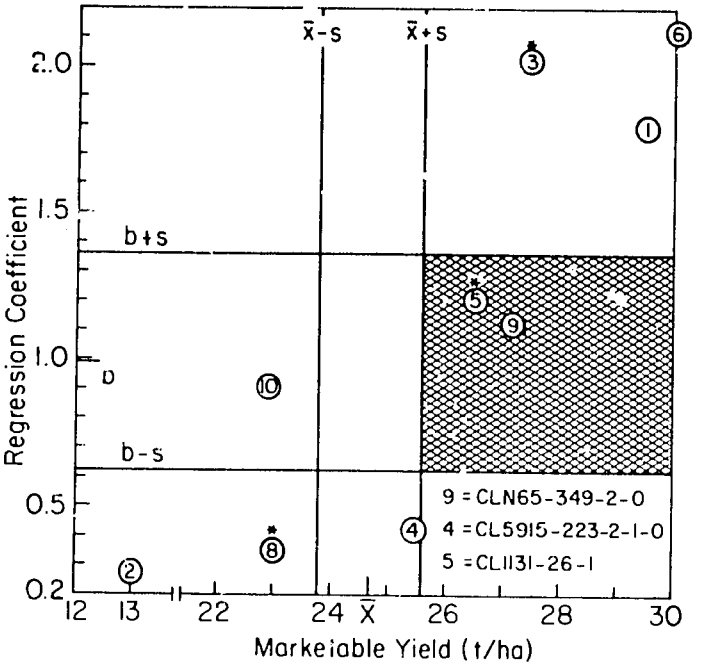

Fig. 2.
Relationship of marketable yield and stability among advanced yield trial entries, AVRDC 1985. (Note: Significant deviation from regression (s^2d) is indicated by an asterisk above each entry.

above-average yield, and insignificant deviation from regression (s^2d). This type of cultivar should fall in the shaded region of the figure. As may be noted, only two lines are in this area, namely: CLN 65-349-2-0 and CL 1131-26-1-0-1-0. However, the deviation from regression of the latter was significant.

Of interest is CL 5915-223-2-1-0 whose regression coefficient is lower than 1, implying that it performed similarly across environments. However, its yield was not considerably high, just falling short of transgressing the upper bounds of the average yield of all entries.

The apparent stability of CLN 65-349-2-0 extends to other traits such as total yield, fruit set, maturity, fruit load (number per plant), and fruit size. For these traits, this line gave regression coefficients not statistically different from unity and an s^2d that was insignificant. Its only unstable character was plant stand.

Processing tomato hybrids. One hybrid, PT 1017, dramatically outperformed both check cultivars in the hot season trial (Table 13). Its main advantage over the checks was its inherent ability to set fruit under high temperatures, thus, resulting in higher early yield. Although the difference in the final fruit-setting rates between TK 70 and PT 1017 did not appear to account well for the 'better than ten times' difference in yield, much of the improvement in fruit set of TK 70 occurred in later stages of growth when ambient temperatures became milder. The extremely poor performance of Tainan No. 2 can be attributed not only to its heat sensitivity but also to its susceptibility to viral and fungal diseases which largely affected the trial.

Conclusion

Three hybrids from 33 F1 hybrid combinations performed better than the commercial hybrid checks but did not differ statistically from the best-performing tropical parent line, CL 5915-206-2-5. When combinations were between heat-tolerant stocks, more hybrids outperformed the tropical parent lines although their fruit sizes, in general, were smaller than those of the hybrids between tropical lines and temperate-bred cultivars. A cursory analysis of gene action trends implied that both additive and nonadditive gene action underlie the expression of heat tolerance as previously found in the 1983 diallel experiments.

Table 13. Performance of new processing tomato hybrids vs. check cultivars, AVRDC, summer 1985.

Entry	Days to		Early Yield (t/ha)		Final Yield (t/ha)		Fruit-	Fruit
	flowering	maturity	total	marketable	total	marketable	Set (%)	Size (g)
PT 1017	14 d	82 b	16.25 a	15.40 a	28.78 a	23.57 a	36.1 a	51
TK-70 (check A)	25 a-c	80 b	0.26 c	0.21 c	3.28 d	1.85 d	9.8 d	60
Tainan 2 (check B)	27 ab	96 a	0.03 c	0.03 c	1.81 d	1.33 d	0.4 e	64
Grand Mean	24	85	4.45	4.18	14.21	11.09	17.5	59
CV (%)	12	2	43.44	43.05	16.37	18.89	15.1	13

Three entries from 30 new lines outperformed the tropical check lines. The best of these were CLN 65-349-2-1-0 and its sister line, CLN 65-349-2-2-0, both of which showed lower bacterial leafspot damage, resistance to fruit cracking, and firm fruits of improved size compared to the older tropical check line, CL 1131-13-0-6.

In general, none of the 21 new lines outperformed the tropical check line CL 1131-13-0-6. However, the best of the new lines that performed similarly to the check line had the advantages of bearing larger, firm fruits without cracking problems, especially those belonging to the CLN 65 series.

Based on average marketable yields across four trials, three lines from 10 advanced entries were rated the best: CL 5915-93-1-0, CL 5915-223-2-1-0, and CLN 65-349-2-0. An analysis of stability showed that the best among these lines was CLN 65-349-2-0 which showed stable performance in nearly all analyzed characters, except in plant stand. The essential advantages of this line, apart from its generally stable yielding ability, include: lower bacterial leafspot infection, improved fruit size, improved firmness, and absence of fruit cracking.

Out of eight processing tomato hybrids, PT 1017, strikingly outperformed both check cultivars. The main advantage of this hybrid over the checks was its better fruit-setting ability during the hot period than the rest of the entries.

International Cooperation

We continued our firm commitment to provide national programs and other interested parties with improved tomato germplasm. In 1985, we distributed a total of 3,574 seed packets to 254 cooperators in 76 countries. Fifty-two percent of the total distribution went to cooperators in Asia. A comparative seed distribution chart for the last five years is given in Fig. 3. In 1985, we began receiving performance reports on the new series of tropical lines, as well as older lines, that we provided to our cooperators as early as 1983.

Bangladesh. The Mennonite Central Committee (MCC) which has been testing AVRDC tropical lines for many years now, screened 13 new lines at Feni in 1985. Check cultivars were Roma VF and Marglobe. The trial was sown on 14 October 1984 and transplanted on 14 November 1984.

Two lines outyielded Marglobe but not Roma VF (Table 14). CL 5915-93-1-0 was the highest total yielder and bore fruits comparable in size to Roma VF. The tropical lines generally had much higher culled fruits (attributed in this trial to sun-scald), thereby reducing their final marketable yield. The MCC is continuing their tests of these new lines.

Botswana. The Department of Agricultural Research at Gaborone evaluated four AVRDC processing hybrids against standard cultivar Velox and processing hybrid Castleprize VFN in the 1984-85 summer season. PT 1575 and PT 1576 had comparable, if not better, yield and fruit size relative to Velox. No comparison was made of preharvest and postharvest fruit characteristics that are normally important for processing.

In another trial involving three indeterminate tropical lines from AVRDC, one standard cultivar (Piersol), and six introduced fresh-market cultivars, CL 5915-206D4-2-3-0 yielded as well as other

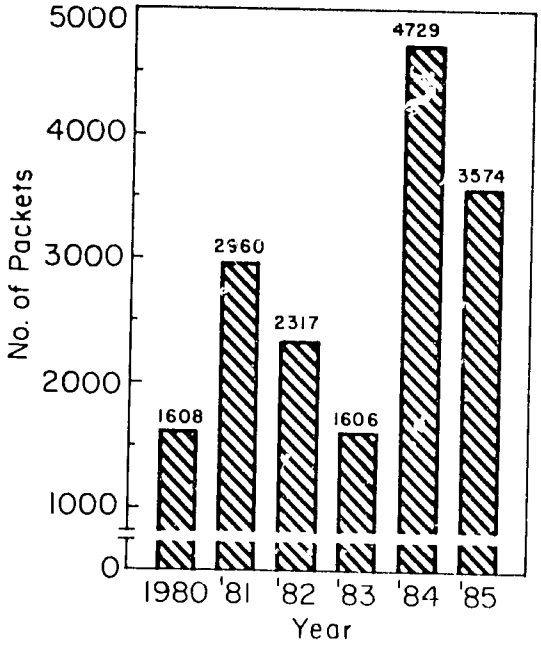

Fig. 3.
Number of seed packets distributed to international cooperators, 1980-85.

Table 14. Performance of AVRDC tropical lines vs. check cultivars in Feni, Bangladesh, 1985.

Entry	Days flowering	Days maturity	Total Yield (t/ha)	Cull[z] (%)	Fruit-Set Rating[y]	Fruit Size (g)	Diseases[x] LB	TMV	LCV
CL 5915-93-1-0	35	83-113	71.2	34	5	47	4	1	3
CL 5915-314-1-1-0	34	95-113	63.6	29	5	29	3	1	2
Roma VF (check)	37	98-114	63.1	7	4	48	3	1	1
Marglobe (check)	40	95-113	48.6	17	4	102	3	2	2
Grand Mean	–	–	55.3	23	–	39	–	–	–
LSD (5%)	–	–	14.0	18	–	7	–	–	–
CV (%)	–	–	12	36	–	8	–	–	–

[z]On weight basis. [y]Based on 1-5 scale: 1 = no set, 5 = heavy set. [x]Based on 1-5 scale: 1 = no symptom; 5 = all plants severely infected; LB = late blight; TMV = tomato mosaic virus; LCV = leafcurl virus.

non-AVRDC entries. However, its fruit size was the smallest among the fresh market entries. Moreover, it does not carry resistance to common root knot nematode, unlike the standard cultivar Piersol.

Brunei. The Sinaut Agricultural Training Center conducted three unreplicated trials of AVRDC tropical lines in 1984 and 1985. The first trial (August-November 1984 cropping season) consisted of nine lines. The best lines from the trial were included in a trial of 14 lines during the February-May 1985 cropping season. The third trial consisted only of the best entries from the previous trials and was conducted during the July-October 1985 cropping season.

The best entries in the 1984 trial are listed in Table 15. CL 5915-93-1-0 gave the best yields (total and marketable), the highest fruit set, and nearly the largest fruit size among all entries. This line also exhibited fruit crack resistance.

CL 143-10-3 was the highest yielder in the second trial but showed a lower level of resistance to bacterial wilt and smaller fruit size than CL 5915-93-1-0 (Table 16). Although KingKong F1 (check) bore the largest fruit, it had the poorest fruit set and, consequently, the lowest yield among the entries. Its bacterial wilt resistance was comparable to CL 143-10-3.

Results of the third trial are given in Table 17. In general, the performance of the selected entries

Table 15. Performance of AVRDC tropical breeding lines at Sinaut, Brunei (August-November 1984).

Entry	Days to flowering	Days to 1st harv.	Yield (t/ha) total	Yield (t/ha) marketable	Fruit-Set Rate[z]	Fruit Size (g)	Cracking[y]
CL 5915-93-1-0	31	56	48	39	4	46	1
CL 5915-153-3-3	31	56	32	26	2	34	2
CL 9-0-0-1-3	27	56	30	26	3	42	1
S 24-1[x]	23	56	28	23	3	42	2
S 24-7[x]	23	56	27	20	2	48	1

[z]Based on 1-5 scale: 1 = no set, 5 = heavy set. [y]Based on 1-5 scale: 1 = no cracking, 5 = severe.
[x]Selections from AVRDC accessions originally introduced into Sembawang Research Station, Singapore.

Table 16. Performance of AVRDC tropical breeding lines at Sinaut, Brunei (February-May 1985 trial).

Entry	Days to flowering	Days to 1st harv.	Marketable[z] Yield (t/ha)	Fruit-Set Rate[y]	Fruit Size (g)	Leafspot Rating[x]	Bacterial Wilt[w] (%)
CL 143-10-3	26	61	30	5	21	3	10
CL 5915-93-1-0	26	61	25	4	36	2	0
CL 5915-153-3-3	31	61	15	3	25	3	0
CL 9-0-0-1-3	31	61	16	3	33	3	20
S 24-1	26	61	15	3	47	2	0
S 24-7	31	63	18	3	28	2	0
Kingkong F1 (check)	41	69	9	2	60	2	10

[z]Adjusted yield. [y]Based on 1-5 scale: 1 = no set, 5 = heavy set. [x]Reported as grey leafspot; based on 1-5 scale: 1 = resistant, 5 = very susceptible. [w]Recorded at first harvest.

Table 17. Performance of AVRDC tropical breeding lines at Sinaut, Brunei (July-October 1985).

Entry	Days to 1st Harv.	Marketable[z] Yield(t/ha)	Fruit-Set Rating[y]	Fruit Size (g)	Bacterial Wilt[x]
CL 143-10-3	68	45	4	35	4
CL 5915-93-1-0	68	43	4	51	0
CL 5915-153-3-3	68	44	4	42	8
CL 9-0-0-1-3-0	68	45	4	24	0
S 24-1	68	48	5	51	0
S 24-7	71	43	5	63	0

[z]Adjusted yield. [x]Recorded at first harvest. [y]Based on 1-5 scale: 1 = no set, 5 = heavy set.

in this test was better than in the previous trials. The highest yielder was S 24-1, but yield differences among the entries were small.

According to our cooperator, Dr. Ramon Santiago, all entries listed in Table 17 will be recommended for large-scale demonstration trials in 1986 in preparation for release to growers. Among the selected entries, CL 5915-93-1-0 appeared to be the most promising, with stable, high yields in three trials; excellent resistance to bacterial wilt; improved fruit size and other good characteristics, such as crack resistance and firmness.

Cook Island. Mr. K. Turepu, a long time cooperator for testing AVRDC tropical breeding lines at Rarotonga, compared 37 tropical lines with commercial varieties such as C 330, YR 816, YR 880, and Caraibe. The trial was sown on 13 June 1984 and transplanted on 18 July 1984. Design was randomized complete block with four replications. Three lines compared favorably with the commercial varieties (Table 18). The best line was CL 5915-206-2-1 which outyielded all the commercial cultivars and produced the largest fruits among the entries.

Table 18. Performance of AVRDC tropical breeding lines at Rarotonga, Cock Island 1984.

Entry	Days to		Yield (t/ha)		Fruit-Set Rate	Fruit Size (g)
	1st harv.	maturity	total	marketable		
CL 5915-206-2-1	62 a-d	82	39.9 a	39.8 a	5 a	144 a
CL 5915-206-2-5	64 ab	80	31.8 b	31.5 b	5 a	125 b
CL 5915-229-1-1-0	59 g-f	75	27.0 b-e	26.2 c-e	5 a	68 g-i
C 330	61 c-g	79	27.2 b-d	27.0 b-d	5 a	121 b-d
YR 816	59 g	77	26.5 c-e	26.4 b-e	5 a	95 ef
YR 880	61 b-g	78	23.9 d-h	23.7 d-h	3 c	97 e
Caraibe	61 b-g	79	21.6 d-j	21.5 d-j	5 a	85 f
Grand Mean	62	78	21.3	20.9	4	73
CV (%)	3	9	15	17	12	11

In terms of quality, the best tropical lines were considered excellent for local use but inadequate for export purposes because their flesh (pericarp) thickness was considered inadequate for long transport. Mr. Turepu is continuing the test of the selected tropical lines with particular emphasis on off-season production in 1986

Fiji. The Sigatoka Research Station (cooperator: Mr. M. Iqbal) released two AVRDC tropical lines for commercial production in the past. These lines, named 'Alton' and 'Sada Bahar' were noted for their heat tolerance and bacterial wilt resistance. In 1984, seven new commercial varieties from seed companies and 29 new tropical breeding lines from AVRDC were screened to select more promising cultivars. Design was randomized complete block with three replications.

Of the tropical lines, 10 were selected for further trials along with one commercial cultivar, Redlands Summer Taste which had the highest yield of 15.5 t/ha. Among the tropical lines, CL 5915-223D4-3-1-0 gave the highest yield of 11.8 t/ha. The selected entries possessed good 'tolerance' to bacterial wilt and had round, firm fruits ripening uniformly.

Ghana. Ten tropical lines were compared with local variety Laureno in a trial conducted by William Azorliade of Irrigation Development Authority at Ahumadan-Ashanti. The trial, transplanted on 31 December 1984 had generally low yields. Although not statistically different from that of the check cultivar, two lines appeared to have the potential to outyield the latter. Fruit size of these lines were, however, smaller than that of the check.

Guatemala. Mr. Carlos Cajas of ICTA (Instituto de Ciencia y Tecnologia Agricolas) selected four tropical lines from previous trials for testing in three hot, humid locations at Zacapa in 1985. These locations were Oasis, Cabanas, and Barranco Colorado. Two tropical lines were considered to have only comparable yields as 'Gamad' and 'Chico III' even though they possessed better fruit-setting ability (Table 19).

Table 19. Average performance of selected tropical lines in three locations Zacapa, Guatemala 1985.

Entry	Marketable Yield (t/ha)	Fruit-Set (%)	Soluble Solids	pH
CL 5915-153D4-3-3	20.8	70	3.6	4.2
CL 5915-153D4-3-4	19.3	68	3.8	4.2
Gamad	20.7	51	3.6	4.3
Chico III	23.4	45	3.5	4.3

Haiti. The ROC Agricultural Technical Mission tested two processing hybrids against check cultivars Roma and Floradade in a trial sown on 10 July and transplanted on 7 August 1985 at Croix-des-Bouquettes. The design was randomized complete block with three replications. Yields of all entries

in this trial were drastically low. The best yielder under the adverse conditions of the test was PT 1461 which also tended to produce the largest fruits among the entries. The adverse test condition was probably best attested to by the zero yield of check cultivar Floradade.

India . Dr. C. R. Ramesh, plant pathologist of ICAR (Central Agricultural Research Institute) conducted an unreplicated observational trial of 28 breeding lines and accessions under the hot, humid tropical location of Port Blair. Resistance to common diseases in the area (bacterial wilt, Septoria leafspot, *Alternaria*, powdery mildew, and virus complex unspecified) and horticultural traits (growth habit, fruit size, shape, crack resistance, and firmness) were noted.

Eighteen entries (two accessions and 16 breeding lines) were rated immune (no wilting) to natural wilt infection. The rest were either highly resistant (1-10% wilt) or moderately resistant (11-50% wilt) except three entries which were considered highly susceptible (71-100% wilt). Consideration of other diseases and horticultural characters (crack resistance and firmness) narrowed down the number of outstanding lines or accessions to the best five entries as follows: L96, CL 5915-153D4-3-6, CL 5915-222D4-[illegible]0-4-0, CL 5915-39D4-1-4-0, and CL 5915-223D4-3-2-0. These lines, apart from the observed immunity to bacterial wilt, showed no cracking problems, had some fruit firmness, and were less infected than other entries by *Alternaria*, Septoria leafspot, powdery mildew and the virus complex common at Port Blair.

Indonesia. Dr. Sri Setiati Harjadi of Bogor Agricultural University (IPB) tested 10 determinate and 6 indeterminate tropical lines against local check cultivars at Tajur, Bogor. The determinate lines were tested three times (three different planting dates) and the indeterminate lines, once. 'Intan' (an AVRDC accession released by the Indonesian national program in 1980) and an unidentified local variety served as check cultivars. For indeterminate lines, 'Moneymaker' and a similar local cultivar were used as checks. All trials were considered preliminary and were not replicated.

The average performance of some of the determinate lines compared with the checks is given in Table 20. Two lines, CL 1131-43-8-1 and CL 5915-93-1, appeared to be comparable if not better than 'Intan'. All lines including 'Intan', were superior to the local check which generally showed the highest bacterial wilt infection rate among entries. CL 1131-43-8-1 had the highest level of wilt resistance but also bore the smallest fruits.

Table 20. Average performance of determinate AVRDC tropical breeding lines in three unreplicated tests at Tajur, Bogor, Indonesia 1984.[z]

Entry	Days to Flowering	Yield (t/ha) total	Yield (t/ha) marketable	Fruit-Set Rating[y]	Fruit Size (g)	Bacterial Wilt (%)[x]
CL 1131-43-8-1	13	16	12	5	20	2
CL 1131-7-2-11	15	7	6	3	28	24
CL 5915-93-1	15	12	9	3	39	6
Intan (check)	15	11	9	2	38	13
Local (check)	21	4	3	2	31	33

[z]Transplanted on 14 August, 9 September and 8 October, 1984. [y]Based on 1-5 scale: 1 = no set; 5 = heavy set. [x]Average of two trials only.

For improved fruit size without loss of bacterial wilt resistance, CL 5915-93-1 is the more superior line. Although not reported in these trials, this line has the added advantages of carrying ToMV resistance, fruit-cracking resistance, and good firmness which the better check cultivar, Intan, does not possess.

None of the indeterminate lines outperformed the local check cultivar, although their relative advantages over the other check, 'Moneymaker,' were obvious. Lines CL 5915-206-2-1 and CL 5915-206-2-4 produced larger fruits than the local check; however, they had only slight, if any, advantage in terms of bacterial wilt resistance. CL 5915-553-3 had the highest wilt resistance level but its fruits were the smallest among the entries. 'Moneymaker' was the most susceptible to bacterial wilt.

Kampuchea. The Christian World Service Program in Kampuchea (cooperator: Dr. Brent Rowell) tested 12 topical breeding lines, 5 commercial cultivars from the United States, 1 introduction from Thailand, and 2 locally grown varieties at Phnom Penh in 1984-85. Entries were sown on 13 November 1984, transplanted on 11 December, 1984, and harvested from 24 January to 7 March 1985. Experimental design was randomized complete block with two replications.

Of the 12 tropical lines, eight will be definitely included in the subsequent confirmatory trials along with commercial cultivars Pacesetter 502 (Asgrow Seed Company) and Tropical (Peto Seed Company). The highest marketable yield of 21.8 t/ha was obtained from CL 1131-0-0-65-13-0-1. In contrast, 'Pacesetter 502' and 'Tropical' yielded 14.0 and 12.5 t/ha, respectively. However, fruit sizes of the latter were three to four times larger than that of CL 1131-0-0-65-13-0-1.

The best local variety yielded 7.3 t/ha with an average fruit size of 45 g. Only tropical lines CL 5915-223D4-2-1 and CL 5915-93D4-1-0, both selected for future testing, compared favorably with the local cultivar in terms of fruit size. These lines gave an average fruit weight of 45 and 44 g, respectively. Bacterial wilt was not considered a major problem during this planting season.

Malawi. Two trials of AVRDC tropical lines were conducted by our cooperators at two locations in Malawi. The first trial of 10 lines compared with locally grown cultivars Moneymaker and Heinz, was carried out at Nkhotakota by Small Holder Sugar Authority. This trial was sown on 26 May and transplanted on 20 June using a randomized complete block with three replications. The second trial was conducted by B.D.K. Mpighu of Lilongwe Agricultural Development Division at Nathenje and consisted of five lines compared with check cultivar Floradade. This trial was sown on 3 October, and transplanted on 28 October, 1984 with a randomized complete block design having three replications.

Three lines yielded well although not statistically better than the check cultivars at Nkhotakota (Table 21). The reported disadvantage of the tropical lines is their inferior fruit size compared to the commercially grown cultivars.

Yields of tropical lines and check cultivar Floradade at Nathenje were inexplicably low. CL 5915-206-2-1 and CL 5915-206-2-3 are preferred, however, and continuing trials in 1984 are planned. These lines outyielded 'Floradade' in the trial although their fruit sizes were visibly inferior.

Table 21. Performance of AVRDC tropical breeding lines in Nkhotakota, Malawi, 1984.

Entry	Days to flowering	Days to maturity	Marketable Yield (t/ha)	Fruit Size (g)
CL 1131-13-0-6	24 c	82 ab	53	36 ef
CL 1131-7-2-0	24 c	82 ab	49	51 c-e
CL 5915-153-3-4	24 c	82 ab	46	47 c-f
Moneymaker (check)	30 a	77 bc	43	71 b
Heinz (check)	28 b	71 c	34	171 a
Grand Mean	25	81	42	59
CV (%)	4	4	21	14

Malaysia. Four tropical lines were compared against check cultivar, Pink No. 28, in a trial at Sabah conducted by Ms. Liaw Hiew Lian of the Agriculture Research Center. The trial, using a randomized complete block design with three replications, was sown on 23 April, and transplanted on 6 June, 1985.

The best tropical lines which markedly outperformed cv. Pink No.28 (check) are listed in Table 22. CL 143-10-3-1 gave the highest yield and the least cracking problem. However, its fruit was considered too small for the prevailing market standard at Sabah. Although its blossom-end rot problem is more pronounced than the other tropical lines, CL 9-0-0-1-3 is considered the most acceptable line because of its relatively large fruit size.

Martinique. Eighteen tropical breeding lines and four accessions were evaluated by IRAT-Martinique scientists for resistance to bacterial wilt and general horticultural characteristics of utmost

Table 22. Performance of AVRDC tropical breeding lines at Sabah, Malaysia.

Entry	Days to Flowering	Yield (t/ha)[z] total	Yield (t/ha)[z] marketable	Fruit Size (g)	Cracking (%)	Blossom End Rot (%)
CL 1131-43-4-12	9	34	25	23	19	7
CL 143-10-3-1	10	31	26	25	1	20
CL 9-0-0-1-3	14	32	21	39	5	29
CL 1104-29-1	14	15	14	31	3	9
Pink No.28 (check)	21	5	2	51	8	44
V (%)	4	20	20	17	31	15
LSD (5%)	1	9	7	11	4	6

[z]Adjusted yield

importance in that country. 'Caraibe,' a widely grown bacterial wilt-resistant cultivar, and 'Marglobe,' a highly susceptible cultivar, were used as checks.

Bacterial wilt resistance was assessed through artificial inoculation of 10^{8} bacterial cells per pot at the time of transplanting. Entries were sown on sterilized medium on 21 February, transferred to pots on 3 March, and transplanted to the field on 22 March 1985. Design was randomized complete block with two replications. The trial was harvested from 14 May to 10 June 1985.

Eleven lines were very resistant, showing no wilt symptoms throughout the growth period, while four possessed good tolerance, averaging less than 15% infection (Table 23). In contrast, the check cultivar Marglobe showed 100% mortality.

Considering overall characteristics such as wilt resistance, firmness, fruit cracking, resistance to blossom end rot, and good vegetative vigor, the following lines were considered to be the most outstanding: CL 1219-0-8, CL 1131-0-0-7-2-0-9, CL 9-0-0-1-3, CL 5915-206D4-2-3, CL 5915-206D4-2-2, and CL 5915-93D4-1-0. In contrast to the bacterial wilt resistant commercial cultivar Caraibe, these lines showed better crack resistance (CL 5915-93D4-1-0 showed no fruit cracking), better firmness (CL 1219-0-8 was rated very firm fruited while others were rated firm), and better resistance to blossom end rot (cv. Caraibe was considered susceptible to this disorder).

Table 23. Reaction of tropical breeding lines to bacterial wilt inoculation at Martinique, 1985.

Reaction	Line or Accession Number
Highly resistant	L 366, L 285, CL 1351-1-9-10-0, CL 1219-0-8-0, CL 8d-0-7-1, CL 9-0-0-1-3, CL 1131-0-0-43-8-1, CL 1131-0-0-7-2-0-9, CL 5915-93D4-10, CL 5915-223D4-2-1
Tolerant	CL 5915-206D4-2-1, CL 5915-206D4-2-3, CL 5915-206D4-2-5 and CL 5915-136D4-1-0

Mexico. Two sets of unreplicated observational trials were conducted by Mr. J. Enriques-Retes of INIA (Instituto Nacional de Investigaciones Agricolas) at Los Mochis, Sinaloa to select genotypes with high fruit-setting potential, yield, and disease resistance. The first set comprised of determinate tropical breeding lines compared with UC 82-C as check. The second set was made up of indeterminate tropical breeding lines compared with the same check cultivar, UC 82-C. Among the determinate lines, CL 5915-153-3-4 and CL 5915-153-3-3-0 both gave numerically higher yields than UC 82-C, even though fruit setting rates were the same. These lines, however, bore smaller fruits than UC 82-C.

Four indeterminate lines (CL 5915-206-2-1-0, CL 5915-206-2-4-0, CL 5915-206-2-5-0, and CL 5915-553-3-0) had pronounced higher yields than UC 82-C (check). Of these lines, only CL 5915-553-3-0 had noticeably smaller fruits than UC 82-C. Others had fruits slightly larger, if not similar, than UC 82-C.

Presently, INIA is using AVRDC tropical lines in the breeding program to develop processing tomatoes with better yield and quality for Sinaloa.

In another observational trial of tropical lines at Ciapan conducted from 1984-85, the superiority of most lines over check cultivar UC 82B in terms of heat tolerance was again demonstrated. The best yielder was CL 5915-206D4-2-4-0, an indeterminate line, yielding 137 t/ha and with a mean fruit size of 65 g. In contrast, check cultivar UC 82B yielded 82 t/ha with a mean fruit size of 60 g.

The best determinate tropical line was CL 5915-153D4-3-4 which yielded 102 t/ha with an average fruit weight of 39 g. With the exception of some large-fruited indeterminate lines, the fruit size of most tropical lines was considered generally small. However, their high level of heat tolerance makes them outstanding parental stocks for the breeding program to develop heat-tolerant processing tomato for Sinaloa.

Philippines. Three trials were conducted by the AVRDC-Philippine Outreach Program at Los Baños on AVRDC processing hybrids and accessions. The first trial (Set F) comprised 10 hybrids compared with check cultivars Marikit, Tainan No. 2, and TK 70. This trial, using a randomized complete block design with five replications, was sown on 23 November, and transplanted on 17 December 1984.

The second trial (Set G) consisted of seven nematode-resistant accessions which were compared with check cultivars Marikit and CL 2826-2-0-1-0. This set was sown on 22 November, and transplanted on 17 December 1984; the design was randomized complete block with two replications. The third trial (Set H) was sown on 22 November, and transplanted on 17 December 1984 with a similar experimental set-up as the first trial. Entries for this trial consisted of six hybrids compared with check cultivars Marikit and Tainan No. 2.

PT 744 and TM 103 were the best yielders in Set F (Table 24). However, their overall performance was not markedly different from 'Marikit' although pronouncedly better than Tainan No. 2 and TK 70.

Exceptionally high yields were obtained in Set H (Table 25) with PT 1599 outperforming both check cultivars, Marikit and Tainan No. 2. Another hybrid, PT 1017, also did well but its performance was not appreciably better than check cultivar Marikit despite the magnitude of their yield difference. In general, fruit sizes of all entries were similar.

Table 24. Performance of AVRDC processing tomato lines (Set F) in POP, Economic Garden, Los Baños, Philippines 1985.

Entry	Days to Flowering	Yield (t/ha) total	Yield (t/ha) marketable	Fruit-Set Rate[z]	Fruit Size (g)
PT 744	25	31.3 a	30.8 a	3.8	36 cd
TM 103	26	29.3 ab	28.8 a	4.0	54 b-d
Marikit (check)	26	27.8 ab	27.4 ab	3.6	43 b-d
Tainan No. 2 (check)	27	21.9 b-d	21.2 bc	3.0	61 b
TK 70 (check)	24	14.5 ef	13.9 e	4.2	54 b-d
Grand Mean	28	22.4	21.8	3.4	55
V (%)	8	23.2	23.6	26.0	29

[z]Based on 1-5 scale: 1 = no set; 5 = heavy set.

Table 25. Performance of AVRDC processing tomato lines (set H) at POP, Economic Garden, Los Baños, Philippines, 1985.

Entry	Days to Flowering	Marketable Yield (t/ha)	Fruit-Set Rate[z]	Fruit Size (g)
PT 1599	29 c	121.2 a	4.0 a	46
PT 1017	30 bc	108.1 ab	3.8 ab	45
Marikit (Ck)	30 bc	78.4 bc	3.4 a-c	43
Tainan 2 (Ck)	32 ab	62.2 c	3.0 b-d	52
Grand Mean	31	82.2	3.3	53
CV (%)	7	29.6	18.8	15

[z]Based on 1-5 scale: 1 = no set; 5 = heavy set.

Two nematode-resistant accessions, L 97 and L 274, compared favorably with check cultivars Marikit and CL 2826-2-0-1-0 in overall performance in Set G (Table 26). L 274, in particular, tended to produce larger fruits than other entries and showed wilt reaction comparable to that of Marikit.

Another trial of processing tomato hybrids was conducted by RAM Food Products at Pulo, Cabuyao, Laguna. This trial consisted of eight hybrids and two check cultivars, Tainan No. 2 and CL 2784-1-1-4. The trial was sown on 11 December 1984 and transplanted on 9 January 1985; the design was randomized complete block with three replications. PT 870 and TM 103 had the best performance among the new hybrids. Both hybrids markedly outyielded Tainan No. 2. However, only PT 870 had appreciably higher yield than the other check, CL 2784-1-1-4. Both PT 870 and TM 103 showed no fruit cracking problem and their fruit-setting ability tended to be better, though not significantly, than either check cultivars.

Reunion. In the last three years, scientists at IRAT (Institut Recherches Agronomique Tropical) have been testing tomato lines that were selected and released by AVRDC cooperators in Seychelles and Mauritius. A number of these lines tested in two locations from 1982 to 1984 are considered promising and will be proposed for cultivation in the hot, humid season (Table 27). MST 32-1, selected by scientists of the Mauritius Sugar Industry Research Institute (MSIRI) from AVRDC breeding materials, has already been released under the name 'Eureka'.

Table 26. Performance of some accessions and breeding lines (set G) in POP, Economic Garden, Los Baños, Philippines 1985.

Entry	Days to Flowering	Marketable Yield (t/ha)	Fruit-Set Rate[z]	Fruit Size (g)	Bacterial Wilt[y]
Marikit (Ck)	27 d	38	3.0	43	2.0
L 97	32 ab	34	3.5	64	3.0
L 274	30 b-d	31	2.5	101	2.0
CL 2826-2-0-1-0 (Ck)	27 d	26	3.0	58	2.5
Grand Mean	31	21	2.5	67	2.9
CV (%)	5	25	20.0	42	23.8

[z]Based on 1-5 scale: 1 = no set, 5 = heavy set. [y]Based on 1-5 scale: 1 = no infection; 5 = severe.

Table 27. Performance of lines derived from AVRDC breeding materials in two locations in Reunion, 1982-1984.

Variety	Ligne Paradise (150 m)						Les Chimacons (800 m)			
	1982			1984			1983			
	bacterial wilt[z] (%)	total production (t/ha)	fruit size (g/ft)	bacterial wilt[z] (%)	total production (t/ha)	fruit size (g/ft)	bacterial wilt[z] (%)	total production (t/ha)	fruit size (g/ft)	late blight infection[y]
MST 32-1	28	11	32	26	24	33	0	16	37	3
MST 21-23	25	11	41	35	18	40	0	21	46	2
Canner	15	14	34	24	19	33	0	17	35	3
Caraube	25	5	80	19	19	61	0	24	91	2
Roma (check)	98	0	-	100	0	-	49	11	44	2

[z]Recorded two months after transplanting. [y]Based on 1-5 scale: 1 = resistant, 5 = highly susceptible.

The principal defect of this line is its small fruit size and susceptibility to late blight at a high elevation. 'Canner', another selection from AVRDC materials released in Seychelles, has similar characteristics but has not yet been released.

MST 21-23, also a selection of MSIRI from AVRDC materials, is already grown commercially by a private enterprise under the name 'Bourbonna'. This line produces bigger fruits than other MST lines and is less susceptible to late blight. However, its fruit shape and size are sometimes irregular. All of the above lines carry acceptable levels of resistance to bacterial wilt and good fruit-set in the

hot season. Caraibe, a variety obtained from INRA (Antilles), had good resistance to bacterial wilt and medium-sized fruit. However, its yield in the lowland is reported to be occasionally poor, especially when fruit-setting coincides with high temperature.

In a new set of trial materials, CL 1104-13 has been selected for further testing.

Solomon Islands. A trial of 16 AVRDC tropical breeding lines and two check cultivars was conducted by the Agricultural Technical Team of the Republic of China at Honiara in 1985. Experimental design was randomized complete block with three replications. Three lines (CL 9-0-0-1-3, CL 5915-206D4-2-2, and CL 5915-206D4-2-5) were considered to be high yielding and suitable for production in Solomon Islands.

Table 28 compares the general performance of these lines with the two check cultivars, Bonny Best and Beef Steak. As may be noted, the advantages of the tropical lines over these temperate-bred cultivars were great. Other tropical lines that performed relatively well were CL 1131-0-0-43-8-1 and CL 143-0-10-3-0-1-10. However, these lines bore small fruits and were only moderately resistant to bacterial wilt.

Taiwan. Six hybrid processing lines were tested against check cultivar TSS No. 1 as possible fresh market cultivars by the District Agricultural Improvement Station at Penghu. Trial was sown on 1 April, and transplanted on 4 May, 1985 using a randomized complete block design with three replications. Two hybrids, PT 744 and PT 862, outperformed TSS No. 1 mainly because of their better fruit-setting ability (Table 29). Fruit sizes of the processing hybrids were not statistically different from that of TSS No. 1, although the latter tended to produce relatively larger fruits.

Tanzania. Nine tropical lines were compared against locally grown cultivars, Moneymaker and Roma, in a trial conducted by Sokoine University of Agriculture at Morogoro. The trial was transplanted on 27 June 1984. CL 5915-93-1-0 outyielded both check cultivars and produced fruits nearly comparable in size to that of Moneymaker and larger than that of Roma. Like Roma, however, high cull yield due to *Heliothis* and sunscald damage reduced its final marketable yield advantage over the more popularly grown Moneymaker.

Thailand. Adams International tested four AVRDC processing tomatoes against a commercially grown check cultivar, VF 134-1-2 and a newly introduced hybrid, P 502, from Asgrow Seed Company. Sowing and transplanting dates were 15 December, and 8 January, 1985, respectively. Design was randomized complete block with four replications. The best performing hybrid was PT 1600 which outyielded all entries. Apart from its good yielding ability, this hybrid also had good fruit firmness and excellent resistance to bacterial wilt. Tainan No. 2, another processing variety from AVRDC, had comparable performance to the check. However, it produced about 12% dwarf, unfruitful types which depressed its general performance.

Table 28. Performance of tropical lines at Honiara, Solomon Islands 1985.

Entry	Marketable Yield (t/ha)	Cracking (%)	Fruit Size (g)	Bacterial Wilt Resistance
CL 9-0-0-1-3	28.6	3	60	strong
CL 5915-206D4-2-2	26.4	3	90	strong
CL 5915-206D4-2-5	25.8	5	75	strong
Bonny Best (check)	0	–	–	very weak
Beef Steak (check)	0	–	–	very weak

Table 29. Performance of processing hybrids against check cultivar in Penghu, Taiwan, 1985.

Entry	Total Yield (t/ha)	Fruit-Set (%)	Fruit Size (g)
PT 744	24.5 a	62 ab	95
PT 862	19.4 b	66 a	102
TSS No. 1	13.4 d	48 c	111
Grand Mean	15.2	55	93
CV (%)	10.7	10	14

Tomato Entomology

In 1985, entomological research activities in tomato dealt with host plant resistance and sex pheromone studies with tomato fruitworm, *Heliothis armigera* (Lepidoptera: Noctuidae).

Tomato Fruitworm Resistance in Segregating Populations

Tomato fruitworm is a polyphagous insect that attacks tomatoes in Southeast Asia. The insect lays eggs on tomato leaves and the early-instar larvae feed on foliage before infesting the fruits on which the major damage is inflicted. In 1980 we confirmed the fruitworm resistance of two *Lycopersicon hirsutum* f. *glabratum* accessions which have shown resistance to other lepidopterous pests elsewhere. Our plant breeders have crossed these materials with their high-yielding, disease-resistant breeding lines.

Based on our screening of the BC2F2 population in late 1984, our plant breeders made further backcrosses in early 1985 to improve fruit size which was small in the resistant progeny. In late December we received the BC3F2 seeds and they are now being planted to study the inheritance of resistance and to select resistant progeny with good horticultural traits. The results will be reported next year.

Screening Hairy Tomatoes for Resistance to Tomato Fruitworm

Introduction

In 1982 AVRDC received seeds of tomato lines which had excessive pubescence on the foliage and stems. These materials were screened for aphid resistance, the results of which were reported in last year's annual review. The same planting materials were screened for tomato fruitworm in early 1985.

Materials and Methods

Seeds of each entry were sown in plastic cups containing a soil-and-compost mixture. The seedlings were raised for one month in the greenhouse. A 0.05 ha of land was rototilled and worked into 1.5-m-wide beds. These beds were further divided into 10-m-long plots. The seeds of each entry were transplanted as a single row on three randomly selected plots, each plot representing one replicate.

The crop was grown according to traditional practices, except the use of insecticides. At harvest, when all entries had set fruit, most of which were already mature, fruitworm damage and the total number of fruits in each plot were recorded. The data on damaged fruit percentage were analyzed by Duncan's multiple range test to test the difference among entries.

Results and Discussion

The results of fruitworm infestation are summarized in Table 1. All hairy tomato entries suffered considerable fruitworm damage. There were no significant differences in damage among the hairy tomato entries and TK 70, a standard susceptible cultivar. Least damaged was cv. 76W PI 134417, as in the past tests. Like this entry the hairy tomatoes have excessive pubescence, but lack the glandular trichomes and possibly the toxic chemical which are responsible for the resistance of 76W PI 134417 to tomato fruitworm.

Table 1. Infestation of hairy tomatoes by tomato fruitworm.[z]

Entry	Fruit Damage (%)	Entry	Fruit Damage (%)
PT 1630	20.35 a	PT 1632	15.49 a
PT 1631	19.06 a	PT 1626	15.33 a
PT 1394	18.78 a	PT 1627	14.88 a
PT 1629	18.28 a	TK 5[y]	8.48 ab
PT 1633	17.88 a	76W PI 134417[x]	0.14 b

[z]PT entries have excessive hairs on foliage, stems, and fruits. [y]Susceptible check.
[x]Resistant check.

Conclusion

Certain tomato accessions with excessive pubescence on the foliage and stems were screened for resistance to tomato fruitworm, along with TK 70 (susceptible) and 76W PI 134417 (resistant). The excessively pubescent tomatoes suffered greater fruitworm damage than 76W PI 134417, AVRDC's standard resistant check, and even more than TK 70, AVRDC's standard susceptible check.

Mass-Rearing and Preliminary Sex Pheromone Studies on Tomato Fruitworm

Introduction

Among the insect pests that require constant attention is tomato fruitworm (TFW), a polyphagous insect that attacks several economically important crops worldwide. In Taiwan, it is a serious pest of tomato which is grown in 10,000 ha. At present farmers use large quantities of insecticides to combat this pest. This has resulted in significantly increased production cost and in the potential development of insect resistance to the chemicals. The danger on human health and environment has not yet been assessed thoroughly.

On 1 November 1983, AVRDC joined an interdisciplinary team sponsored by the National Science Council of Taiwan to develop sex pheromones to combat this pest. This progress report summarizes AVRDC's research during 1985.

Materials and Methods

Mass rearing. Based on the experience of the first year, AVRDC continued to use an artificial diet marketed by BioServ in the United States. The premixed diet was diluted in agar-water adjusted to 70°C before cooling. The newly emerged adults, after two to three days' confinement in a cage containing a tomato plant, readily laid eggs on paper.

The 1st instar larvae were released on the diet. The diet is changed five to six times before pupation. Just before prepupal stage, the fully grown larvae were transferred to a glass jar containing moistened and finely sieved soil. The insect readily pupated in the soil. The pupae were removed by passing the soil through an appropriate mesh sieve; then they were sexed and mailed for sex pheromone extraction.

In the absence of synthetic sex pheromone, the following studies were conducted with virgin females as the pheromone source. These studies were done in a 0.8-ha tomato field where no insecticide was used.

Trap design and height. The three types of traps commonly available in Taiwan were used. The water-trough trap is readily obtainable in the market. The virgin females, two to four days old, were confined in a perforated plastic container which was attached to the uppermost part inside the trap. The lower part was filled with water mixed with a detergent. The males attracted to the virgin female fell into the water in the trough.

The sticky paper trap is also readily available in the market. The lower part of this trap was covered with sticky glue. The perforated container holding virgin females was placed at the uppermost part inside it. The males were trapped in the sticky glue.

The PET bottle trap is carved out of disposable polyethylene bottles of a popular soft drink. The lower detachable part of the bottle was separated and a false bottom steel wire net placed in the upper part of the bottle to hold virgin females. The detachable bottom is then replaced and holes of a suitable size were made to permit the moth to enter but not to escape. Virgin females were placed in the upper part of the bottle above the steel wire net.

The traps were placed in the field 1 m above the soil surface every evening after 5:00 P.M., and the number of male moths caught were recorded for five consecutive days. This experiment was carried out on three different tomato fields on the AVRDC experimental farm.

The sticky paper traps holding virgin females, two to four days old, were placed at 1, 2, 3, and 4 m above the soil surface. A minimum of 20 m distance was maintained between two traps. The number of males caught in each trap was recorded over three consecutive days.

Pheromone concentration. Traps containing 1, 3, 5, 8 (3 + 5), 10 (5 + 5), and 15 (5 + 5 + 5) females, two to four days old, were placed at 1 m above the soil surface in the field. A distance of 20 m was maintained between two traps. The number of male moths captured in four consecutive days was recorded.

Virgin female and male ages. Traps containing five females, from freshly emerged (0 day old) to 10 days old, were placed 1 m above the soil surface. The number of male moths caught in four days was recorded. In a similar study virgin females, one to seven days old, were placed in an identical manner and the number of males caught was recorded similarly.

Males freshly emerged and up to seven days were marked on their wings with various shades of color to indicate their age. These insects were then released in the field 5 m distance from a trap containing five virgin females. The number of moths of various ages caught in the traps was recorded in three days.

Effective distance. A trap containing five virgin females was placed in the center of the field. Male moths were placed on tomato plants at 1, 5, 10, 20, 30, 40, and 50 m from the baited trap in two directions: against and with the wind. The moths were marked on their wings with various color patterns to indicate their release site from the trap. The insects were placed on one tomato plant which was covered with a nylon net bag to prevent their escape during the day. The bags were opened at dusk and the virgin females placed in the trap at the center of the field. The number of moths placed at various distances and caught in the trap was recorded.

Results and Discussion

Mass rearing. As of 31 December 1985, the following institutes were supplied TFW pupae for sex pheromone studies:

	male	female
1. Yang Ming Medical College	8570	14979
2. Academia Sinica	7692	3952
3. Fu Jen University	850	450
Total	17112	19381

A total of 36,493 pupae has been supplied until now. Although insects grow normally and vigorously on the artificial diet, at times in the larval stage just before pupation, very high mortality rates (up to 80%) have occurred. We are trying to rectify the problem by modifying the diet.

Sex pheromone studies. The following are the number of adult males caught in each type of trap in five days:

Water trough trap	12.00
Sticky paper trap	9.00
PET bottle	8.00

The number of male moths caught in all three traps was statistically similar. Since the sticky paper trap is easily obtainable and easier to use, it will be used for future studies. AVRDC will attempt to determine how many of the attracted males are actually caught in this type of trap.

The results of the trap height study are summarized in Table 2. More male moths were caught in traps placed at 1, 2, and 3 m than in those placed 4 m above the ground. The largest number of insects was caught in 1-m high traps; however, there was no significant differences in number among heights. In future studies, therefore, the traps will be placed 1 m above the soil surface.

Table 2. Influence of trap height on the capture of male TFW moths.[z]

Trap Placement (above soil surface)	No. of Males (during 3 days)
1 m	22.4 a
2 m	17.8 ab
3 m	12.2 ab
4 m	7.0 b

[z]The means in the vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test

The number of males caught by various virgin female moths (pheromone concentration) per trap is summarized in Tables 3 and 4. The number of males captured increased as the number of virgin females per trap increased. There was, however, no significant difference between the numbers of males caught by 5 and 15 females per trap; so, 5 to 15 insects will be used in future work.

Tables 5 and 6 summarize the 'amount' of sex pheromones produced by virgin females of different ages, according to the number of males caught at a particular date. Two- to six-day-old virgin females attracted the largest number of males. In future studies for comparison with synthetic pheromones, virgin females of these ages will be used

Table 3. Capture of males in traps baited with various numbers of virgin females (study I).[z]

No. of Virgin Females/Trap	No. of Males/Day (ave. 4 days)
3 x 5	12.25 a
2 x 5	11.00 ab
3 + 5	10.00 abc
5	9.00 abc
3	6.00 bc
1	5.00 c

[z]The means in the vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Table 4. Capture of males in traps baited with various numbers of virgin females (study II).[z]

No. of Virgin Females/Trap	No. of Males (during 6 days)
15	31.0 a
3 x 5	30.0 a
10	20.0 a
2 x 5	22.3 a
5	20.6 a
0	0.0 b

[z]The means in the vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Table 5. Response of male fruitworm moths to virgin females of various ages (study I).

Date	No. Males Caught by Females of Various Ages										
	0	1	2	3	4	5	6	7	8	9	10 (days)
11 – 21 – 84	0	0	0	1	–	–	–	–	–	–	–
11 – 22 – 84	–	0	0	3	0	–	–	–	–	–	–
11 – 23 – 84	–	0	2	3	1	1	–	–	–	–	–
11 – 24 – 84	–	–	0	5	2	2	1	–	–	–	–
11 – 25 – 84	–	–	–	8	1	4	1	2	–	–	–
11 – 26 – 84	–	–	–	–	9	0	3	1	1	–	–
11 – 27 – 84	–	–	–	–	–	7	5	4	3	1	–
11 – 28 – 84	–	–	–	–	–	–	9	2	1	0	0

Table 6. Response of male fruitworm moths to virgin female moths of various ages (study II).

Date	No. Males Caught by Females of Various Ages							
	ck	1	2	3	4	5	6	7 (days)
11 – 26 – 84	0	0	1	0	14	–	–	–
11 – 27 – 84	0	–	13	5	10	12	–	–
11 – 28 – 84	0	–	–	7	10	6	6	–
11 – 29 – 84	0	–	–	–	9	2	4	6

Results of male response by age to the female sex pheromone are summarized in Table 7. Three- to five-day-old moths were caught more frequently than the moths which were younger or older. These data are useful in the laboratory bioassay of candidate pheromone compounds.

On the effective area of pheromone activity, marked males released at up to 50 m from the female trap at both against and with the wind, were caught. The results of this test were not consistent, however; in some instances, insects released at greater distances were caught while those at shorter distances were not.

In an enclosed screenhouse erected in the tomato field, only 47 to 65% of the intentionally released males were caught over a five-day period.

The results of these preliminary tests will be used to compare the potency of synthetic sex pheromones with the naturally produced ones and to evaluate the effectiveness of synthetic sex pheromones in the field.

Table 7. Age of male moths responding to sex pheromones.

Date	Percentage of Marked Males of Various Ages Caught (days)						
	1	2	3	4	5	6	7
12 – 24 – 84	0	0	0	23.08	15.79		
12 – 25 – 84	–	0	25.00	25.00	25.00	15.63	
12 – 26 – 84	–	–	0	33.33	0	6.67	11.11

Conclusion

AVRDC joined an interdisciplinary team of entomologists and chemist to utilize sex pheromones for tomato fruitworm control. These 1985 data on trap design, trap height, pheromone concentration, and ages of active reproduction for both sexes will be used in the 1986 studies on synthetic sex pheromones.

Tomato Pathology

Late Blight on Tomato

Introduction

Late blight of tomato (caused by *Phytophthora infestans*) is a problem of tomatoes grown in highland tropical areas. For the past two years, we have investigated a tomato accession, L 1197, that shows partial resistance to this pathogen. So far, we have been able to incite epidemics on the susceptible cultivar, TK 70, but not on L 1197 under field conditions. In 1985, an attempt was made once again to produce epidemics in both lines with the sprinkler irrigation.

Materials and Methods

Seeds of both L 1197 and TK 70 were sown on 21 January 1985 and the resulting seedlings were transplanted on 22 February. There were two plots for each cultivar. Plots were separated by a strip of maize to minimize interplot interference. All plantings were inoculated on 1 April by placing four infected plants in each plot. An overhead sprinkler irrigation was applied for 5 min six times a day to facilitate disease development. Disease ratings were taken at regular intervals using a modification of a potato disease assessment key, and these data analyzed through a linear regression of logit disease over time (days after inoculation).

Results and Discussion

As in the past, the epidemic only developed on TK 70. Plots of the raw data and data transformed to logit are presented in Figs. 1 and 2. When all points were used in the regression, untransformed data gave an R-squared value of 91.9%, while a value of 93.5% was obtained for the transformed data. Since there are good *a priori* reasons for the logit transformation, this was the transformation of choice.

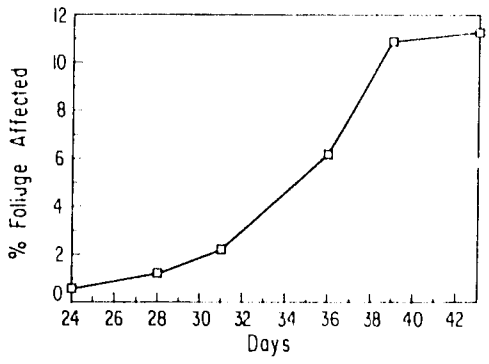

Fig. 1. Late blight epidemic on TK 70.

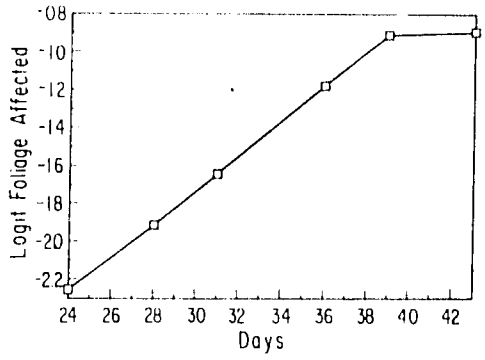

Fig. 2. Late blight epidemic on TK 70 (data transformed to logit).

Although disease had only reached 10% of the leaf area infected at day 43, the temperature was much higher this spring; and conditions were no longer suitable for late blight development. This is evident from the dropping of the regression line, even with the transformed data. Elimination of this last reading gave an even better fit, with an R-squared value of 96.3%. An ANOVA table from MINITAB for the transformed data without day 43 is presented in Table 1.

Table 1. ANOVA and regression equation for TK 70.

The Regression Equation is Logit = - 4.53 + 0.0928 Day

Column	Coefficient	St. Dev. of Coef.	T-ratop = Coef/S.D.
	-4.5268	0.2075	-21.82
Day	0.092836	0.006472	14.34

S = 0.1103

R-Squared 96.3%
R-Squared = 95.8%, adjusted for D.F.

Analysis of variance

Due to	DF	SS	MS = SS/DF
Regression	1	2.5028	2.5028
Residual	8	0.0973	0.0122
Total	9	2.6001	

The slope this year was .09, which compares favorably with the value from last year, .11. This slope (from logit transformed data) is the rate of disease increase in epidemiological models. Since the final amount of disease was very low, care should be exercised in making inferences about the rate of disease increase.

Although these studies provide an excellent way to study partial resistance in tomato lines, the partial resistance of L 1197 is sufficiently high to prevent any epidemics from developing. Much of the susceptibility that was observed in variety trial studies was undoubtedly due to interplot interference where susceptible entries would increase the amount of incoming inoculum on the partially resistant ones. In pure stands, L 1197 provides very good levels of resistance, since in testing for more than one season we have been unable to initiate epidemics, even with suitable source plants and an overhead sprinkler irrigation.

If derived lines have lesser amounts of resistance, similar studies may be necessary to quantify their resistance under field conditions.

Conclusion

As in previous years, the late blight epidemic only developed in the susceptible line, TK 70. Apparently, L 1197 provides very good levels of resistance to late blight.

Testing Tomato for Bacterial Wilt Resistance by Infectivity Titrations

Introduction

Accurate assessment of relative resistance and susceptibility of tomato lines to bacterial wilt (caused by *Pseudomonas solanacearum*) has been the primary goal of the bacterial wilt project. This consisted of both field testing and limited studies on selected lines under slightly more controlled conditions. The infectivity titration method was adopted, and although this complicated subsequent analysis, results were in general, satisfactory.

Materials and Methods

Standard methods were used to produce uniform seedlings. Seeds of test materials and the resistant and susceptible checks were sown on 4 February, and germinating seeds were transplanted on 7 February. Ten seedlings were inoculated on 8 March with 4 to 10 doses of *P. solanacearum*, total log 10 doses ranging from 3.5 to 8 CFU, depending on the number of seedlings available. Inoculated plants were kept in a heated greenhouse, and the number of wilted plants for each dose cultivar combination was recorded on 25 March.

While programs written in MBASIC have been developed for the analysis of infectivity titrations, the last set of data was analyzed by GLIM on the HP 3000. The data were arranged in a large rectangular matrix, the columns being log doses, total plants tested, number wilted, and number for cultivar or line. The number of rows for each cultivar varied, it being also the number of doses used, and was dependent on the number of plants available (Table 2). A minimum of four and a maximum of ten doses were used.

Table 2. Sample GLIM program to analyze data.[2]

```
$UNITS 118
$VAR DOSE TOTAL WILT
$FACTOR VAR 15
$DATA DOSE TOTAL WILT VAR
$DINPUT 12 80
$ERROR B TOTAL
$LINK P
$YVAR WILT
$FIT VAR %GM + DOSE $DISPLAY E $LOOK %X2 $
$FIT VAR %GM + VAR DOSE $DISPLAY E $LOOK %X2 $
$DISPLAY R $
```

[2]This assumes a FIT command under MPE that designs the data file to FORTRAN channel 12, 118 total observations, and 15 varieties tested.

To perform the analysis, GLIM was given the vector length (the number of rows) and appropriate variables set up for dose, total, and number of plants wilting. The cultivar or line was set up as a 'factor', with the maximum level being 15 (the number of lines tested). The error function was set to binomial (with the denominator being the number of plants in the 'total' column), and the probit option was used in the link statement. The dependent variable was, of course, wilt. Two models were fitted, one with a 'common slope, separate intercept', and the other with a 'separate slope, separate intercept' for each of the lines.

Commonly, chi square values are used to evaluate the models. These values do not appear as the 'deviance' of the model, but can be obtained by printing the value corresponding to '%X2'. Another difference between the GLIM probit analysis and more conventional ones is that the calculated probit values are centered around zero. Thus, while most probit tables will give a probit of 5 for a 50% response, GLIM assigns this a value of 0. This needs to be taken into account when calculating ED 50 values, although the differences between lines (relative potency etc.) can be estimated in the usual manner. Of course, ED 50 values can be obtained from the GLIM output by merely dividing the intercept estimate by the slope.

Results and Discussion

The differences in the chi square value (and the appropriate degrees of freedom) were used to test for parallelism of the lines. In this case, the chi square value was a little too large to allow the assumption of parallelism (Table 3). An examination of the separate slopes showed that two lines, CLN 95-77-2-0 and CLN 95-280-1-0, had very small slopes (one was practically flat); whereas the others were in the range of .28 to 1. Elimination of these two lines (using a prior weight vector) gave much better results in the parallelism test, but hardly affected the final results (Table 4).

The difference in log dose between each of the the lines and L 285 and L 390 was calculated by taking the difference in the intercept values, and dividing it by the common slope.

Most lines were intermediate to L 285 and L 390, and CLN 65-349-2-0 showed a response line that was only about two units (representing a 100 fold difference) from L 285. Total range (in log dose) was roughly 7 to 8 (Table 5).

Table 3. Deviance in probit analysis models with all test lines included in the analysis.

Model	Chi-Square	df
Parallel line	167.2	102
Separate line	140.5	88
Difference	26.7	14

Table 4. Deviance in probit analysis models with CLN 95-77-2-0 and CLN 92-280-1-0 eliminated from the analysis.

Model	Chi-Square	df
Parallel Line	131.0	91
Separate Line	118.1	79
Difference	12.9	12

Table 5. Intercepts and LD 50 values from the common slope model (CLN 95-77-2-0 and CLN 95-280-1-0 included.[z]

Line	Intercept	LOG LD 50	Difference between L 285	L 390
CLN 65-349-1-0	- 1.623	3.967245	6.29430	1.910780
CLN 65-349-2-0	-3.265	7.980934	2.28062	5.924468
CLN 91-139-1-0	- 1.839	4.495233	5.76632	2.438768
CLN 91-338-1-0	- 1.768	4.321682	5.93987	2.265216
CLN 91-392-1-0	- 1.98	4.839892	-5.42166	2.783427
CLN 91-392-2-0	- 1.977	4.832559	-5.42899	2.776094
CLN 91-392-3-0	- 1.401	3.424591	6.83696	1.368125
CLN 95-77-1-0	- 1.878	4.590565	5.67099	2.534099
CLN 95-77-2-0	- 2.779	6.792960	3.46859	4.736495
CLN 95-280-1-0	- 2.107	5.150330	5.11122	3.093865
CLN 95-280-3-0	- 1.535	3.752139	6.50941	1.695673
CLN 95-59-1-0	- 2	4.888780	5.37277	2.832315
CLN 95-264-1-0	- 1.375	3.361036	-6.90051	1.304571
L 285	- 4.198	10.261550	0	8.205084
L 390	- .8413	2.056465	- 8.20508	0

[z]Common slope .4091.

Conclusion

Accurate assessment of relative resistance and susceptibility of tomato lines to bacterial wilt has been a primary goal of the bacterial wilt project. The infectivity titration method was adopted and generally gave satisfactory results. All lines showed an intermediate level of resistance between L 390 (susceptible check) and L 285 (resistant check). The most resistant breeding line was CLN 65-349-2-0.

Screening for Resistance and Seed Transmission of Potato Virus Y

Introduction

Because of the high incidence of potato virus Y (PVY) on tomato in Taiwan and other tropical countries, its synergistic reaction with other viruses, notably CMV, and the lack of commercial cultivars possessing resistance to this virus, a program was initiated to screen the germplasm collection for sources of resistance. We also tested seed transmission of PVY in tomato since no information is available on this subject.

Materials and Methods

For resistance screening, 15 to 30 plants of 19 randomly selected accessions, comprising mainly wild tomato lines such as *Lycopersicon pimpinellifolium*, *L. peruvianum* and *L. hirsutum* (Acc. Nos. 139, 177, 181, 593, 610, 632, 667, 675, 677, 690, 691, 697, 735, 898, 3234, 3683, and VL 75, VL 74, VL 82) were screened by the method described previously.* Two *L. hirsutum* lines (VL111 and Acc. No. 3683) found to be resistant in the 1984 screening were also rescreened in 1985.

For seed transmission, plants of tomato cultivar TK 70 were inoculated with PVY isolate NT5 and seeds of infected plants were collected. Fifty batches of 100 seeds each were tested directly by grinding the seeds in Na phosphate buffer pH 7.0 and subjecting them to an ELISA test. Another fifty batches of seeds were tested after their germination in moist petri dishes.

Results and Discussion

None of the 19 accessions was found resistant after two consecutive artificial inoculations. Confirmed was the resistance of accessions 3683 (*L. hirsutum* PI 365903) which yielded one infected plant out of 16 inoculated plants and of VL 111 (*L. hirsutum* PI 247087) which yielded six infected plants out of 135 inoculated plants in the second screening. These accessions will be subjected to one more screening test, using a mixture of all 24 presently available PVY isolates (which is expected to include different strains) to determine whether the resistance is strain specific.

The results of the combined 1984 and 1985 screenings indicate that among wild tomatoes, resistance gene(s) are available from *L. hirsutum*. However, only two of the 14 *L. hirsutum* lines tested (PI 365903 and PI 247087) proved to be resistant.

There was no indication of seed transmission in 5,000 seeds of cultivar TK 70 tested directly and 5,000 seeds tested after germination. Other cultivars will have to be tested to determine whether this finding is true for other cultivars as well.

Conclusion

Only one accession (Acc. 3683) and one line (VL 111) of the 20 lines with reported resistance to PVY, were found to be resistant. The resistance mechanism of these two lines will be studied for subsequent usefulness in AVRDC's breeding program.

Resistance Screening, Mechanical Transmission, and Purification of the Taiwan Tomato Leaf Curl Virus

Introduction

Tomato yellow leaf curl caused by a whitefly transmitted gemini virus is the most important disease of tomato in the Near East and certain regions in Africa and Asia. Yield reductions of up to 80% have been reported. Commercial cultivars with resistance to this virus are not yet available. We have found for the first time, a similar whitefly transmitted gemini virus causing a leaf curl disease of tomato in Taiwan.

The host range, which was determined by grafting and whitefly transmission, included *Datura stramonium*, *Nicotiana benthamiana*, *Petunia hybrida*, *Physalis* [illegible] *Solanum tuberosum* and *Lonicera japonica*. In this study, several tomato lines with potential resistance to tomato yellow leaf curl virus were screened with the tomato leaf curl virus of Taiwan. Efforts to transmit the causal agent mechanically and to purify it were attempted.

*AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

Materials and Methods

Resistance screening. Eight cultivated and wild tomato lines with reported resistance to the tomato yellow leaf curl virus were tested. Scions of six to ten plants of each line were grafted to *Nicotiana benthamiana*, infected 20 days before with the Taiwan leaf curl virus. After three weeks, the grafted scions were cut off above the graft union and back-grafted to healthy *N. benthamiana*. The grafted tobacco plants were observed for three to four weeks for symptom development.

Mechanical transmission. For sap transmission, leaf curl infected tissue of *N. benthamiana* and *L. esculentum* was homogenized in 0.01M Na phosphate buffer (pH 8.0). Twenty plants each of *N. benthamiana* and *L. esculentum* Acc. 213, known to produce strong symptoms, were inoculated with this homogenate. Half of the inoculated plants were kept in a 26°C growth chamber (10-h day, 15,000 lux 14-h night) and the other half, in the screenhouse and observed for three to four weeks for symptom expression.

Purification. Six methods which have been used successfully to isolate gemini type viruses have been tried. The first method consisted of grinding the tissue in phosphate buffer (pH 7.2), with EDTA as the stabilizing agent (Cohen et al. 1983).* This was followed by clarification in 10% chloroform, precipitation by PEG, and one cycle of low- and high-speed centrifugation. Final purification was by linear sucrose density gradient.

In the second method, the sample was ground in trisodium citrate buffer (pH 7.0), amended with EDTA, mercaptoethanol, and ascorbic acid as the stabilizing agents (Stein et al. 1983).** Clarification was by Triton X. This was followed by one cycle of low- and high-speed centrifugation, sucrose cushion pelleting, and final purification by linear sucrose density gradient (10 to 50%).

A third method consisted of grinding the tissue in glycine NaOH buffer (pH 7.8), amended with glucose, followed by chloroform-butanol (1:1) clarification, concentration through XM-300 Diaflow system, and one cycle of high- and low-speed centrifugation (Brown and Nelson 1984).

In the fourth method which has been used by the scientists of the International Institute of Tropical Agriculture (IITA)(H. Rossel, personal communication) for the purification of cassava mosaic virus, the virus-infected tissue was ground in 0.1M citrate buffer (pH 7.0), with EDTA, thioglycollic acid, and sodium sulfite as stabilizing agents. This was followed by clarification in chloroform (1:3) and precipitation in 6% PEG. The pellet obtained after one cycle of low- and high-speed centrifugation was layered on a linear sucrose density gradient (10 to 40%) for final purification.

Another method was used, by which gemini particles of bean golden mosaic virus were purified (Goodman et al. 1967)[illegible]. It consisted of grinding the infected tissue in dry ice to a coarse powder, homogenization in phosphate buffer (pH 7.8) amended with EDTA and cystein, and subsequent precipitation by PEG. This was followed by one cycle of low- and high-speed centrifugation and a linear sucrose density gradient (10 to 35%). Instead of dry ice, cool acetone (-4°C) was used for powdering the infected tissue.

The sixth method was that used for the isolation of tobacco leaf curl virus (Osaki and Inouye 1978).† The tissue was ground in sodium phosphate buffer (pH 8.5) with mercaptoethanol as the stabilizing agent, clarified in 10% butanol, precipitated in PEG 600, and further clarified by Triton X-100. This was followed by 10% sucrose cushion centrifugation, reverse concentration, PEG solubility gradient, high-speed centrifugation, and sucrose density centrifugation.

The virus-containing fraction obtained by any of these methods was examined in the electron microscope at 60,000 X after prior fixing in 3% glutaraldehyde.

* Cohen, S., J. E. Duffus, R. C. Larsen, H. Y. Liu, and R. A. Flock. 1983. Purification serology, and vector relationships of squash leaf curl virus, a whitefly-transmitted geminivirus. Phytopathology 73:1669-1673.

** Stein, V. E., R. H. A. Coutts, and K. W. Buck. 1983. Serological studies on tomato golden mosaic virus, a geminivirus. J. Gen. Virol. 64:2493-2498.

Brown, J. K., and M. R. Nelson. 1984. Geminate particles associated with cotton leaf crumple disease in Arizona. Phytopathology 74:987-990.

Goodman, R. M., J. Bird, and P. Thongmeearkom. 1967. An unusual virus-like particle associated with golden yellow mosaic of beans. Phytopathology 67:37-42.

† Osaki, T. and T. Inouye. 1978. Resemblance in morphology and intranuclear appearance of viruses isolated from yellow dwarf diseased tomato and leaf curl diseased tobacco. Ann. Phytopath. Soc. Japan 44:167-178.

Results and Discussion

Resistance screening. Of the eight lines tested, only three showed promise: *L. peruvianum* INRA Sel (VL 115) and two *L. esculentum* (VL 81 and VL 82) (Table 6). These three lines will be subjected to a second graft inoculation test in the greenhouse. Before their use for the breeding program, the resistant plants will be tested again under field conditions in northern Thailand, where both disease and vector pressure is known to be consistently high.

Table 6. Reaction of eight tomato cultivars to the Taiwan leaf curl virus.

Tomato Line	Scions Infected with LCV/ Total No. Tested[z]
L. pimpinellifolium LA 121 (VL 70)	10(10)/10
L. pimpinellifolium LA 121 (VL 71)	7(3)/10
L. pimpinellifolium × *L. hirsutum* (VL 74)	5(4)/8
L. hirsutum B (VL 75)	4(3)/6
L. hirsutum LA 1363 (VL 80)	5(3)/6
L. esculentum LATYLC (VL 81)	4(0)/8
L. esculentum LATYLC (VL 82)	4(2)/8
L. peruvianum INRA SEL (VL 115)	2(0/12)

[z]Numbers in parentheses are those of scions showing symptoms.

Mechanical transmission. None of the 40 mechanically inoculated plants developed any symptoms. This reaction is similar to that reported of all other tomato leaf curl viruses, including tomato yellow leaf curl virus, which cannot be sap transmitted.

Virus purification. None of the six methods tried proved successful for the isolation of the Taiwan leaf curl virus. In the fractions which were supposed to contain the virus, only large amounts of phytoferritin could be seen in the electron microscope. Phytoferritin particles have sedimentation coefficients of 70S to 80S that are similar to those of the gemini particles which have reported sedimentation values of 95S and 76S. Our failure to isolate the virus is attributed partly to an extremely low concentration of the virus within the infected tissue and to the instability of the virus particles during the purification procedure.

By special staining methods, it was recently found that virus particles of the Taiwan tomato leaf curl virus are located within the cell nuclei of infected plants. In the future we will attempt a different purification approach aimed at first isolating purified nuclei, disrupting these by ultrasonication, and then isolating the freed virus particles by sucrose density centrifugation.

Conclusion

It appears that the gene(s) which protect against TYLCV, also protect against the Taiwan leaf curl virus. Purification of the Taiwan leaf curl virus is difficult because of the low concentration of the virus within the tissue and because of the localization of the virus within the nuclei. Further purification attempts will have to put this into account. As long as the antiserum is not available, leaf curl diagnosis and detection has to be done by grafting or electron microscopy.

Screening for CMV Resistance and Using Hairiness as Source of Resistance

Introduction

In the spring of 1984, four tomato lines were evaluated in the field under conditions of natural infection. By the end of the growing season (90 days after transplanting), disease incidence had reached almost 100% in the nonhairy check, but ranged from 34% to 76% in the hairy lines. Infection rates

were significantly lower for the hairy tomato lines.

This second field test was conducted in the spring of 1985 to confirm the results of the 1984 field test. Additional germplasm was also screened for CMV resistance.

Materials and Methods

Screening germplasm for resistance. Thirty or fewer plants of 37 accessions, comprising mainly *L. pimpinellifolium* and *L. pimpinellifolium* x *L. esculentum* (Accs. #, 1024, 3306, 3311, 3367, 3377, 3437, 3512, 3521, 3522, 3545, 3636, 3677, 3708, 3798, 3801, 3819, 3982, 4009, 4059, 4155, 4158, 4159, 4160, 4166, 4167, 4188, 4189, and 4237 to 4246) were screened with Peet's strain of CMV by the method described in the 1984 Progress Report.*

Evaluation of hairiness. Three very hairy lines [PT 1623 line (2-2-2)-1-2-1-1, PT 1627 line (30-8)-1-1-2-1, and PT 1626 line (30-8)-1-1-2-0]; three normal hairy lines [PT 1504 (line (CL 1131) - a processing type breeding line, Ohio MR 13, and KY 372]; and a cross PT 1631 [(2-2-2)-1-2-11 × CL 1131-15-1-0] between a very hairy and a normal hairy line were evaluated in the spring of 1985.

Transplanting to the field was on 3 January. Twenty-five plants of each line were planted in single rows at 40 cm distance. Plot size was 1.5 × 10 m. A completely randomized design with four replications was used. The field was surrounded by five rows of tomato plants planted six weeks prior to the rest of the plants and artificially inoculated with the CMV Peet isolate.

CMV incidence in individual plants was assessed at 40, 54, 68, 82 and 98 days after transplanting, following the procedure described previously.** In addition, the aphid populations on the leaves of the hairy and nonhairy lines were assessed at approximately two weekly intervals by counting the aphids on all the leaves of 15 randomly chosen plants of each line in each replication.

Results and Discussion

All 37 accessions were susceptible producing severe symptoms, such as mosaic and leaf deformation. This confirms our previous observation that genes for CMV resistance are not readily available in wild tomato species. Although the search for differential monogenic vertical resistance genes in wild tomato will continue, other types of small effect resistances have to be explored in the future, which delay symptom development, reduce the rate of CMV replication and distribution within the plants, or support little increase in the disease in the field. The use of cross protection, using either attenuated strains of CMV or Satelite RNA's which have shown an attenuating effect on CMV, may also have to be explored.

Our investigation indicated that at almost all leaf positions, the number of hairs on both upper and lower leaf surfaces was significantly greater on the very hairy lines than on the normal hairy ones. However, in the case of Ohio MR13 (a normal hairy check), the number of hairs on the lower surfaces of the 4th, 8th, and 12th nodes, was similar to that of PT 1627 (a hairy line) (Table 7). Of interest is that in most leaf positions, the number of leaf hairs of the very hairy × normal hairy cross did not significantly differ from that of the very hairy parent, PT 1623. This suggests that high hairiness is a dominant character.

Throughout the growing season, aphid infestation on the very hairy lines and the very hairy x normal hairy cross was significantly lower than on the normal hairy lines (Table 8). However, this low aphid population on the three hairy lines, PT 1627, PT 1626, and PT 1623, was still sufficiently high to produce CMV incidence values which generally did not significantly differ from those of the normally hairy lines (Table 9).

The infection rates (i.e. the rate of disease increase per unit time, sensu vander Plank) of all the very hairy lines were statistically not significantly different from those of all the normal hairy lines (Table 10). Among the normal hairy lines the AVRDC line PT 1504, the nonhairy parent of PT 1631, always had the lowest percentage of CMV infected plants at any time after transplanting; however,

* AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

** AVRDC. 1985 Progress Report. Shanhua, Tainan, Taiwan.

Table 7. Hair number on upper and lower leaf surfaces of normal hairy and very hairy tomato lines and a cross between a normal hairy and a very hairy line.

Tomato Line	No. of Hairs in the Following Leaf Positions									
	4		6		8		10		12	
	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
Normal										
PT 1504	31b	63c	114c	336d	165b	374c	116cd	255d	44c	251c
Ohio MR13	93b	247b	238c	537c	204b	561cb	83d	600c	121c	658b
KY 372	33b	69c	429b	612c	255b	513c	183c	268d	100c	405c
Very Hairy										
PT 1627	498a	350ab	860a	1120a	677a	831ab	587ab	870ab	849a	875ab
PT 1626	566a	475a	858a	979ab	822a	1068a	612ab	985a	769ab	992a
PT 1623	483a	450a	915a	982ab	754a	949a	666a	872ab	705ab	877ab
Very Hairy × Normal Hairy										
PT 1631[z]	567a	454a	823a	908b	717a	908a	552b	714cb	572b	689b

[z]Cross between PT 1504 and PT 1623

Table 8. Aphid population on very hairy and normal hairy tomato lines at different times after transplanting.

Tomato Line	No. of Aphids on the Following Days after Transplanting							
	26	32	40	43	53	61	68	75
Normal								
PT 1504	14.2 a	7.6 a	1.7a	2.9 a	4.0 a	1.9 a	2.4 a	2.2 a
Ohio MR13	8.9 b	5.9 a	1.6a	2.9 a	4.2 a	1.4 ab	1.9 a	1.4 b
KY 372	8.3 b	6.5 a	1.6a	3.3 a	3.4 a	1.1 cb	1.8 a	1.7 ab
Very Hairy								
PT 1627	1.1 c	0.7 b	0.7b	0.7 b	0.7 b	0.7 c	0.6 b	0.5 c
PT 1626	1.7 c	1.0 b	0.7b	1.1 b	0.8 b	0.5 c	0.6 b	0.5 c
PT 1623	1.0 c	0.7 b	0.6b	0.6 b	0.6 b	0.5 c	0.6 b	0.4 c
Very Hairy × Normal Hairy								
PT 1631	1.9 c	1.4 b	0.5b	1.1 b	0.7 b	0.7 c	0.6 b	0.6 c

Table 9. CMV incidence in hairy and nonhairy tomato lines.

Tomato Line	% CMV-Infected Plants days after transplanting				
	41	54	68	82	96
Normal Hairy					
PT 1504	49 ab	69 ab	82 ab	84 a	89 ab
Ohio MR13	68 a	88 a	96 a	98 a	100 a
KY 372	65 a	77 a	91 ab	92 a	94 a
Very hairy					
PT 1627	31 b	61 ab	72 bc	78 ab	91 ab
PT 1626	31 b	59 ab	82 abc	87 a	91 ab
PT 1623	33 b	52 ab	75 abc	80 ab	89 ab
Very hairy × Normal hairy					
PT 1631 (PI 1504 × PT 1623)	29 b	46 b	61 c	63 b	81 b

the difference was not significant at any time after transplanting. Its percentage of CMV infection at the end of the growing season (96 DAT) was also not significantly different from PT 1623, the other very hairy parent of PT 1631, at the end of the growing season (96 DAT).

CMV incidence of the very hairy x normal hairy cross was not found to differ significantly from that of either one of its parents. It was, however, significantly lower at 68 and 82 days after transplanting from that of the normal hairy parent, but not from that of the hairy parent.

Table 10. Progress of disease by days and infection rate of CMV.

Tomato Line	Disease Progress (logit)	Infection Rate (r)
Normal hairy		
PT 1504	−1.30 + 0.0367 days	0.0367
KY 372	−0.79 + 0.0394 days	0.0394
Ohio MR13	−2.14 + 0.0750 days	0.0750
Very hairy		
PT 1627	−2.60 + 0.0505 days	0.0505
PT 1626	−2.69 + 0.0553 days	0.0553
PT 1623	−2.29 + 0.0467 days	0.0469
Very hairy × normal hairy		
PT 1631	−2.37 + 0.0388 days	0.0388

Conclusion

In this field test with high disease and vector pressure, CMV incidence and CMV infection rates of the very hairy tomato lines were not significantly different from those of the normal hairy lines. We believe that hairiness is not a useful measure for CMV control because the significantly lower aphid levels on the very hairy tomatoes apparently do not coincide with significantly lower CMV incidence or rate of CMV infection. Furthermore, the fruits of crosses of very hairy and normally hairy lines are also hairy and unacceptable to the consumer.

Further Characterization of the New Poty Virus

Introduction

One of the four aphid-transmitted poty virus isolates (T 697, T 1077, T 1082, T 704), previously isolated from tomato was purified and antiserum was produced. ISEM serological tests, using antisera to 12 different poty viruses, including seven commonly known to infect tomato, strongly suggested that our virus isolate T 697 is a new, previously undescribed virus. To further characterize the virus and assess its importance, the host range and seed transmissibility were determined in this study.

Materials and Methods

To determine host range, five to ten plants of each plant species or cultivar to be tested were mechanically inoculated with a homogenate of 1 part systemically infected *Nicotiana tabacum* 'Xanthi' in 5 parts 0.01 M Na-phosphate buffer (pH 7.2). The plants were kept in the greenhouse for four weeks and observed for symptom expression. Symptomless plants were tested for latent infection by ELISA.

Seed transmission of the four virus isolates was tested on three foreign tomato cultivars (Floradel, Ohio MR12, Ohio MR13); four local cultivars (TK 70, TN 2, KY 301, and Chin Kan); two AVRDC breeding lines (CL 1131-00-38-1-0 and CL 1131-00-43-8-1); and one AVRDC accession (L 4128A). Twenty plants of each cultivar or line were mechanically inoculated at the primary leaf stage, and seeds of infected plants were collected. Half of the seeds were examined for seed transmission by grinding batches of 50 seeds in 0.1M sodium phosphate buffer and subsequent testing by ELISA. The other half was examined by ELISA in batches of 50 pregerminated seeds, homogenized in the same buffer. Of each line or cultivar, a total of 250 to 300 seeds were tested, both directly and after germination.

Results and Discussion

The host range was identical for all four isolates and was mainly confined to the *Solanaceae* family including *Datura metel*, *D. stramonium*, *Lycium chinense*, *L. halmifolium*, *L. esculentum* cvs. GCR, Delissa, Perou, CSTMW-18, Bonnie Best, *L. pimpinellifolium* cvs. LA 121, Univ. of Missouri Acc.

160, *Nicandra physaloides*, *Nicotiana benthamiana*, *Nicotiana clevelandii*, *Nicotiana debneyi*, *Nicotiana glutinosa*, *Nicotiana sylvestris*, *Nicotiana tabacum* cvs. Xanthi, Xanthi N.C., White Burley, Samsun NN, *Petunia hybrida* cvs. Grandifolia Minstrel, Pink Cascade and *Solanum nigrum*. All isolates produced systemic infection in these hosts. Only two local lesion hosts were identified so far: *Ocimum basilicum* and *S. tuberosum* cv. Duke of York (detached leaves).

The following hosts were found to be immune to this virus: *Beta vulgaris*, *Brassica juncea*, *Capsicum annuum* cvs. Delray Belle, Florida VR-2, Yolo Y, Yolo Wonder, *C. frutescens* Tabasco, Greenleaf Tabasco, McIlhenny, *Chenopodium amaranticolor*, *C. quinoa*, *C. murale*, *Cucumis sativus*, *Gomphrena globosa*, *N. tabacum* cv. V-20, *Phaseolus vulgaris* cvs. Pinto, Toperop, *Physalis peruviana*, *Pisum sativum* cv. Perfected Wales, *Solanum demissum* x *S. tuberosum* cvs. A-6, *Solanum melongena* cv. Pingtung Long, *Solanum tuberosum* cvs. Cardinal, Kennebec, *Tetragonia expansa*, *Vicia faba* minor, *Vigna unguiculata* cv. Black and *Zinnia elegans* cvs. Bright Scarlet, Tetra Ruffled Jumbo.

Besides tomato other economically important crops, such as sweet pepper and chili pepper, were not affected by these three virus isolates. However, more cultivars of these species need to be tested to ascertain this.

Our virus isolates differ from other poty viruses known to infect tomato, such as potato virus Y (PVY), tobacco etch virus (TEV), pepper mottle virus (PeMV), pepper mild mottle virus (PMMV), and Perou tomato virus, in that they do not infect *Chenopodium quinoa*, *C. amaranticolor*, *Capsicum annuum* and *C. frutescens*. On the basis of host range and serological studies we therefore conclude that T697 is a new, previously not reported virus of tomato.

The four isolates were not seed transmitted in any of the 11 tomato lines and cultivars tested (Table 11). An experiment to investigate the effect of this virus on yield of tomato is in the field.

Conclusion

On the basis of host range and serological tests the poty virus isolated from tomato is believed to be a new, previously not reported tomato virus. Since it produces only mild symptoms on tomato its host range is very narrow. It is not seed transmitted in tomato; and since its incidence on tomato in nature is not high, it is not justified at present to incorporate this virus into AVRDC's resistance breeding program.

Table 11. Testing for seed transmission of isolate T697 in 11 tomato lines.

Line or Cultivar	% Seed Transmission[z]	
	seeds	germinated sdlgs.
Foreign Cultivars		
MR12	0(50)	0(50)
MR13	0(50)	0(50)
Floradel	0(650)	0(650)
Local Cultivars		
KY 301	0(400)	0(400)
TK 70	0(650)	0(650)
TN 2	0(250)	0(250)
Chin Kan	0(350)	0(350)
AVRDC Lines		
CL 1131-38-4-0	0(400)	0(400)
CL 1131-43-8-1	0(50)	0(50)
L 4128A	0(200)	0(200)

[z]No. in parenthesis is number of seeds tested

Survival of ToMV in Agricultural Soils

Introduction

In a 1981 survey, the survival of ToMV in 41 agricultural soils where tomatoes were either growing at the time of sampling, or had been grown at various times prior to sampling was studied. The virus

could be recovered in the soil only up to five months after the tomato harvest. This finding is in contrast to that in temperate countries, where ToMV was detectable for several years in agricultural soils. The present study was undertaken to confirm our previous finding that ToMV apparently only survives in southern Taiwan soils up to five months.

Materials and Methods

The same method was used as described previously.[1] Thirty-four fields were sampled where tomato had been harvested more than six months prior to sampling.

Results and Discussion

The combined results of the 1981, 1984, and 1985 surveys are shown in Table 12. ToMV was detected in the soil only up to five months after the tomato harvest. It was not detected in any of the 34 additional soil samples taken from fields where the tomato crop was harvested 8 to 16 months prior to sampling. This may be caused by the rapid breakdown of the tomato crop residue in the soils under southern Taiwan's environmental conditions.

Conclusion

The results of the combined soil survey strongly indicate that ToMV does not survive much more than five months in agricultural soils of southern Taiwan.

Table 12. Survival of ToMV in agricultural soils.

Sampling Time[y]	No. of Fields with ToMV/ No. of Fields Sampled	Sampling Time[y]	No. of Fields with ToMV/ No. of Fields Sampled
0[z]	7/8	9	0/1
1	2/3	10	0/3
2	1/4	11	0/2
3	4/7	12	0/26
4	3/11	13	0/1
5	1/9	14	0/1
6	0/4	16	0/2
8	0/3	Total	16/75

[y]Months after the tomato harvest. [z]At cropping time.

[1] AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

Tomato Physiology

Evaluation of Tomato Pistil Viability under High Temperature Conditions

Introduction

Based on our previous work on the tomato fruit-setting process, pistil viability was considered an important component easily affected by high temperature, thereby leading to poor fruit-set and yield. The varietal factor accounting for the differences in the level of heat tolerance has already been investigated. The extent of varietal difference in pistil viability under high temperature has not been examined, however. This study, therefore, investigated this aspect on heat-tolerant and some commonly grown heat-sensitive tomatoes under high temperature conditions.

Materials and Methods

Twenty-seven entries of AVRDC tomato accessions and breeding lines were sown and transplanted to clay pots (ID 18 cm) at the rate of one plant per pot on 14 June and 8 July 1985, respectively (Table 1). Two stems per plant were maintained, and staked with bamboo sticks. Flowers of the first five clusters were given treatments as follows: 1) natural pollination without any manipulation of flowers, 2) emasculation of flowers one day before anthesis but without artificial pollination, and 3) emasculation of flowers one day before anthesis followed by artificial pollination with mixed, stored pollens which were collected earlier in the cool season.

Flowers were tagged until all in the first five clusters were treated. Data were taken on fruit number, yield per plant, and seed number per fruit. The percentage of flowers with seeded and seedless fruits was calculated.

Results and Discussion

In general, emasculation without artificial pollination did not influence fruit-set rate. However, this treatment reduced fruit yield, whereas emasculation with artificial pollination enhanced it. Emasculation with artificial pollination significantly increased fruit-setting rate more than natural pollination and emasculation without pollination (Table 1). This treatment also produced more seeded fruits than the naturally pollinated tomatoes, but had decreased seed number per fruit. Average fruit size was not affected by emasculation with or without artificial pollination. Therefore, this trait was not listed in the table. As expected, fruit-set in the group of emasculated plants were all parthenocarpic.

The AVRDC improved breeding lines, CL 1131 and CL 5915, had higher fruit-set rate than the unimproved accessions in the natural pollination treatment (Tables 1 and 2). Emasculation without artificial pollination slightly reduced fruit-set rate in unimproved accessions, but increased the rate in CL 1131 and CL 5915. Emasculation with artificial pollination increased fruit-set rate of both unimproved accessions and breeding lines, but the enhancing effect of this treatment was most pronounced in the unimproved, heat-sensitive accessions (Table 2). Improved breeding lines CL 1131 and CL 5915 also had higher fruit yield than the unimproved accessions of naturally pollinated plants.

Table 1. Evaluation of 27 tomato entries on pistil viability by emasculation or pollination.[z]

Entry	Fruit-Set (%)			Parthenocarpic (%)			Yield/Plant(g)			Seed No./Fruit		
	ck	emas	polli	ck	emas	polli	ck	emas	polli	ck	emas	polli
L 6	9 b	14 b	34 a	5 b	14 a	9 b	46 b	42 b	162 a	23 a	0 b	7 b
L 18	18 c	26 a	44 a	12 b	26 a	9 b	72 b	57 b	176 a	3 b	0 c	9 a
L 123	18 b	12 c	40 a	14	12	11	104 ab	54 b	183 a	10 a	0 b	6 ab
L 124	6 b	0 b	70 a	1	0	0	20 b	0 b	237 a	13 a	0 b	11 a
L 125	7 b	9 b	32 a	7 ab	9 a	0 b	18 b	24 b	292 c	–	0 b	13 a
L 142	9 b	7 b	55 a	4	7	2	4 b	1 b	27 a	10 a	0 b	5 a
L 229	23 b	16 b	59 a	13	16	4	58 b	52 b	191 c	3 b	0 c	11 a
L 232	40 b	65 a	69 a	39 b	65 a	1 c	27 c	48 b	135 a	–	0 b	12 a
L 283	17 b	29 a	32 a	9 b	29 a	7 b	88 b	57 b	188 a	6	0	7
L 387	12 b	2 c	27 a	3	2	0	62 b	6 b	152 a	31 a	0 b	17 ab
L 492	20 b	0 c	62 a	11	0	0	18 b	0 c	88 a	12 a	0 b	9 ab
L 1488	12 b	0 c	38 a	0	0	2	30 b	0 c	79 a	14 a	0 c	9 b
L 1834	26 b	9 c	47 a	10 a	9 a	0 b	68 b	34 b	142 a	12 a	0 b	13 a
L 3690	9 b	4 b	79 a	1 b	4 a	5 a	2 b	1 b	15 a	3 b	0 c	6 a
L 3957	25 b	9 c	54 a	11	9	6	97 b	24 c	192 a	21 a	0 c	10 b
L 3958	20 b	19 b	26 a	5 b	19 a	1 b	153 b	38 c	210 a	25 a	0 c	9 b
L 3982	5 b	4 b	45 a	1	4	6	28 b	5 b	203 a	15 a	0 c	9 bC
L 1131-13	59 b	76 a	63 b	39	76 a	5	187 ab	146 b	242 a	8 b	0 c	11 a
CL 1131-26	29 b	72 a	75 a	16 b	72 a	8 b	95 b	105 b	287 a	15 a	0 c	9 b
CL 1131-43	39 b	52 b	70 a	19 b	52 a	6 c	90 b	39 b	282 a	12 a	0 b	9 ab
CL 1131-65	27 c	51 b	59 a	15 b	51 a	11 b	107 b	158 ab	213 a	9 a	0 b	9 a
CL 5915-93	45 ab	41 b	56 a	34 a	41 a	6 b	187 a	81 b	280 a	8 a	0 b	8 a
CL 5915-153	53	70	66	15 b	70 a	9 b	319 a	160 b	285 a	12 a	0 b	7 ab
CL 5915-206	39	41	44	12 b	41 a	7 b	376 a	163 b	394 a	22 a	0 b	7 b
CL 5915-229	41	38	41	40 a	38 a	14 b	241	175	246	–	0 b	7 a
CL 5915-553	41 b	23 c	59 a	12 b	23 a	5 b	236 ab	37 b	258 a	18 a	0 b	14 a
Severianin	14 b	22 a	16 ab	14 a	22 a	4 b	137	162	128	–	0 b	6 a
Mean	24 b	26 b	50 a	13 b	26 a	5 c	106 b	62 c	196 a	13 a	0 c	9 b

[z]Mean separation within rows by Duncan's multiple range test at the 5% level; ck = control; emas = emasculation without pollination; polli = emasculation with artificial pollination.

Table 2. Group comparison of fruit-set, yield, fruit size, and seed number of tomatoes on different pollination treatments.[z]

Group (no. of entries)	Fruit-Set (%)			Part Fruit Set (%)			Yield/Plant (g)			Seed No./Fruit		
	ck	emas	polli	ck	emas	polli	ck	emas	polli	ck	emas	polli
HS accessions (8)	8	5	48	3	5	3	26	10	146	16	-	10
HT accessions (9)	23	21	48	14	21	4	76	40	167	13		10
Breeding lines (9)	41	52	59	22	52	8	204	118	276	17	-	9
Severianin	14	22	16	14	22	4	137	162	128	4		7

[z]ck = control, emas = emasculation without pollination, polli = emasculation with artificial pollination.

However, emasculation without artificial pollination reduced fruit yield of both improved breeding lines and unimproved accessions. Although the extent of increment in fruit yield by emasculation with artificial pollination was higher in the unimproved accessions, the actual fruit yield was still higher in the improved breeding lines. Emasculation with or without artificial pollination did not influence fruit-set rate and yield of a facultative parthenocarpic tomato, Severianin.

Among entries, both CL 5915-153 and CL 5915-206 had the highest fruit yield with natural pollination (Table 1). These two breeding lines also maintained relatively high fruit yield when they were emasculated with or without artificial pollination.

Conclusion

Emasculation with artificial pollination increased fruit set rate, but not fruit size, at high temperature. This is likely due to pollen competition in the artificial pollination treatment. The beneficial effect of emasculation with artificial pollination on fruit set rate was most pronounced in the unimproved accessions. The increased fruit set rate without increasing seed number by emasculation with pollination implies that the pollination itself may have a triggering effect in the initiation of fruit development.

The results also suggest that AVRDC improved breeding lines possess the characteristic of parthenocarpy at high temperature; however, they also possess natural pollination ability which makes them more superior to facultative parthenocarpic tomato, Severianin, in terms of increased fruit-set rate and yield.

In Vitro Evaluation of Pedicel Retention in Tomato

Introduction

Fruit set is a process of ovary growth, as well as the prevention of abscission-layer formation in the pedicel. When a flower fails to be pollinated and/or fertilized, it triggers the formation of this layer. This is usually controlled by the balance and interaction of promotive and inhibitory hormones of the reproductive organs and the rest of the plant. Previously, we reported that L 125 had a strong tendency to retain its pedicel even without reproductive organs. The present study was conducted to evaluate the varietal difference of pedicel retention under *in vitro* conditions.

Materials and Methods

Twenty-seven entries of AVRDC tomato accessions and breeding lines were sown and transplanted to the field on 14 June and 12 July 1985, respectively (Table 3). On 11 August 1985, flower buds with pedicels at three to two days before anthesis were collected from the field. They were sterilized in 0.1% $HgCl_2$ for 5 min and washed with sterilized water three times. Flower buds were cut at the base of the calyx in a laminar-flow cabinet, and the pedicel removed.

The pedicels were then transferred aseptically to a modified MS medium containing 10% sucrose and 0.8% agar in petri dishes (ID 10 cm) which were placed in an incubator at 26°C. Every entry had three replicates which contained 20 pedicels each. Pedicel retention rate was determined on the basis of pedicels without discolored abscission layer at three, six, and eight days after initial culturing.

Table 3. Retention rate (%) of pedicels without reproductive organs under *in vitro* conditions.[z]

Entry	Days after Initial Culture			Entry	Days after Initial Culture		
	3	6	8		3	6	8
L 6	77 e	75 f-i	55 ij	L 3957	93 g-i	73 f-h	17 a-e
L 18	92 f-i	63 ef	32 e-h	L 3958	100 i	83 h-i	35 e-h
L 123	98 i	87 ij	40 g-i	L 3982	57 c	57 de	20 b-f
L 124	100 i	90 i-k	23 c-g	CL 1131-13	97 hi	95 jk	92 l
L 125	100 i	95 jk	70 jk	CL 1131-26	85 e-g	85 h-j	38 f-i
L 142	95 e-i	80 g-i	32 e-h	CL 1131-43	87 fg	73 f-h	55 ij
L 229	88 f-i	63 ef	42 g-i	CL 1131-65	67 e	45 c	8 a-c
L 232	67 d	57 de	42 g-i	CL 5915-93	77 e	65 e-g	32 e-h
L 283	87 fg	72 f-h	50 hi	CL 5915-153	98 i	98 i	98 i
L 387	88 f-i	40 c	10 a-d	CL 5915-206	93 g-i	85 h-j	50 hi
L 492	13 b	5 a	3 ab	CL 5915-229	58 c	43 c	25 c-g
L 1488	83 ef	27 b	17 a-e	CL 5915-553	95 g-i	88 i-k	83 kl
L 1834	95 g-i	49 cd	3 ab	Severianin	95 g-i	83 h-j	28 d-g
L 3690	3 a	0 a	0 a				

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.

Results and Discussion

Data in Table 3 confirm that L 125 had a strong tendency to prevent abscission-layer formation in its pedicel. However, three AVRDC breeding lines, CL 1131-13, CL 5915-153, and CL 5915-553, had even higher pedicel retention rate than L 125 under *in vitro* conditions. Both CL 1131-13 and CL 5915-153 changed very little in their rates in eight days of *in vitro* culturing. Both L 492 and L 3690 had the lowest pedicel retention rate.

Conclusion

Tomato accessions and breeding lines had varietal difference in pedicel retention rate, when their pedicels without reproductive organs were cultured under *in vitro* conditions. Pedicels of a heat-tolerant breeding line, CL 5915-153, did not form any abscission layer in six days of in vitro culturing. Abscission-layer formation in the pedicel seems to play a role in determining the heat tolerance/sensitivity of tomato fruit-setting.

Growth Regulators for Better Summer Yield of Indeterminate Tomatoes

Introduction

Auxins and gibberellins are usually reduced and abscisic acid increased in the reproductive organ of tomatoes grown under high temperature conditions. Auxins and/or gibberellins also improve fruit set and yield under high temperature conditions. However, this enhancing effect is influenced considerably by genetic differences and prevailing temperature conditions.

Because indeterminate tomatoes command high prices in the fresh market, the use of growth regulators to enhance yield seems legitimate. Thus, a field trial was conducted to compare the yields of two indeterminate tomato lines (one tropical line and one heat-sensitive cultivar) applied with growth regulators under hot summer conditions.

Materials and Methods

Two indeterminate tomatoes, CL 5915-206 and L 387 ('White Skin'), were tested in two plantings in this experiment. Materials were sown on 2 May and transplanted on 5 June for the first trial,

and sown on 11 June and transplanted on 11 July 1985 in the second trial. The design was split plot consisting of three replications with growth promoters (GA and/or CPA) as the treatment in the main plot, growth retardants (Alar and CCC) in the subplot, and lines in the sub-subplot. Individual plots consisted of two rows in a bed, each 5.0 m long and spaced 1.5 m apart. Spacing between plants within the row was 40 cm, and between rows was 1 m. Both lines were staked and pruned, and only seven fruiting clusters were maintained per plant.

At seedling stage before transplanting, CCC solution was applied as soil drench at 60 ml/pot, and Alar solution was sprayed on the seedlings to run off. Both CPA (100 mg/l) and GA_3 (400 mg/l) in 0.02% Tween 20 solutions were applied by dipping the whole flower cluster into the solution only once. In the first and second plantings, mean maximum and minimum temperatures were 31.1°C/24.2°C and 31.5°C/23.9°C, respectively, and total precipitations were 524 mm and 596 mm, respectively, from transplanting to harvesting. Horticultural and fruit quality data were measured in the experiments.

Results and Discussion

Both plantings revealed similar results; therefore, only the results of the second planting are discussed here. Table 4 shows that both CPA and GA_3 were effective in evoking fruit setting at high temperature. In this case, GA_3 was more effective than CPA. On the other hand, growth retardants, Alar and CCC, were not effective. As may be noted, CPA, Alar, and CCC significantly increased marketable yield and fruit size. In contrast, GA_3 reduced fruit size. Quality wise, all growth regulators tended to increase total soluble solids. Variation due to genotypic differences was significant in fruit size and yield, where CL 5915-206 had more yield and larger fruit than L 387.

Treatments with CPA on CL 5915-206 gave highest marketable yield of more than 19 t/ha and largest fruit size of more than 85 g/fruit (Table 5). Although GA_3 increased fruit setting rate, it did not increase yield significantly. This may due to small fruit size induced by GA_3. Alar or CCC alone also increased yield of CL 5915-206. Treatments with CPA or GA_3 on L 387 also gave similar results; however, the extent of increment in yield was greater in L 387 than CL 5915-206.

Table 4. Comparison of means of various traits of indeterminate tomatoes in the growth regulator experiment.[z]

Factor	Fruit-Set (%)	Fruit Size (g/fruit)	Yield (t/ha) total	Yield (t/ha) marketable	pH	Brix	Color (a/b)
Main plot							
CPA	29 b	68 a	17 a	16 a	4.2	4.7 ab	0.98
GA_3	40 a	25 d	10 b	9 b	4.2	4.8 a	0.99
CPA + GA_3	32 b	53 b	16 a	15 a	4.2	4.5 bc	0.95
Control	14 c	31 c	10 b	10 b	4.2	4.3 c	0.85
Sub-plot							
Alar	30	43	14 a	13 a	4.2	4.4 b	1.00 a
CCC	28	45	14 a	13 a	4.2	4.7 a	0.98 a
Control	28	45	12 b	11 b	4.2	4.7 a	0.84 b
Sub-subplot							
L 387	27	33 b	7 b	7 b	4.3 a	4.6	0.87 b
CL 5915-206	30	55 a	19 a	17 a	4.2 b	4.6	1.01 a

[z]Mean separation within columns by Duncan's multiple range test at the 5% level

Conclusion

Growing the new indeterminate tropical line, CL 5915-206, with CPA and/or Alar and CCC enhanced its yield potential during the humid summer season. The highest recorded yield was 22 t/ha. CPA increased fruit size of CL 5915-206 by more than double that of the control. Although the yield increment by CPA on L 387 was less than that on CL 5915-206, the extent of increment was greater in L 387 than in CL 5915-206. The results seem to indicate that heat tolerant CL 5915-206 contains more promotive hormones than heat sensitive L 387.

Table 5. Fruit-set, fruit size, and marketable yield of indeterminate tomatoes in the growth regulator experiment.

Chemical	Fruit-Set (%)		Fruit Size (g/fruit)		Yield (t/ha)	
	387	25915-206	387	5915-206	387	5915-206
CPA + Alar	34	31	47	85	12	21
CPA + CCC	26	23	50	88	7	19
CPA	34	26	47	90	11	19
GA_3 + Alar	40	44	20	30	5	15
GA_3 + CCC	40	39	19	30	5	14
GA_3	40	34	19	29	5	12
CPA + GA_3 + Alar	34	30	39	58	11	17
CPA + GA_3 + CCC	30	37	42	64	10	22
CPA + GA_3	29	32	44	68	11	17
Alar	5	23	22	41	2	20
CCC	5	24	26	40	1	18
Control	6	20	24	35	1	14

Effect of Growth Regulators on Fruit-Set and Development with or without Pollination

Introduction

Fruit-set of tomato is triggered by normal pollination and fertilization. At high temperature, normal pollination and fertilization are usually impaired. It also reduces auxin and gibberellin contents and increases the abscisic acid level in tomato flowers and developing fruits. We have demonstrated earlier that artificial pollination at high temperature can bring about fruit-set. It is suspected that pollens may contain certain plant hormones which trigger fruit-set. The present study was conducted to examine the effect of growth regulators, in conjunction with pollination, on fruit-set and fruit development.

Materials and Methods

CL 5915-153 and L 124 (TK 70) were sown and transplanted to clay pots on 31 May and 1 July 1985, respectively. Plants were maintained as double stems and grown under greenhouse conditions. The first four flower buds of cluster 1 to 4 were tagged and applied with respective hormones at three days before anthesis. Later at one day before anthesis, flower buds of CL 5915-153 were emasculated, and on the next day were applied with pollens which were collected in the cool season and stored in the freezer.

Flower buds of L 124 were not emasculated but were artificially pollinated with stored pollens because most stigmas of this entry were exserted. Chemicals were applied by injecting 2 μl 60% ethanolic solution to the base of the calyx, and between the ovary and calyx. Chemicals used were IAA (10 μg/2 μl), ABA (10 μg/2 μl), ethrel (1 μg/2 μl), GA_3 (10 μg/2 μl), kinetin (10 μg/2 μl), mixture of IAA, GA_3, and kinetin at 10 μg each/2 μl. For each treatment, there were four replicates, with four plants each. Mean maximum/minimum temperatures during the experiment were 39.1°C/24.2°C.

Results and Discussion

Among the chemicals tested, only GA_3 was able to enhance fruit-set rate of the naturally and artificially pollinated flowers of both entries (Table 6); ethrel reduced this rate. Ethrel is known to release ethylene in the plant, thereby, causing abscission-layer formation. Apparently, artificial pollination could not overcome this detrimental effect. ABA also tended to reduce fruit-set rate on L 124 with natural pollination. ABA is also known to cause abscission-layer formation, but whether it really plays the same function in tomato needs further confirmation.

Table 6. Effect of pollination and growth regulators on fruit-set, fruit size, and seed number of tomatoes grown in the greenhouse.[z]

Chemical	Fruit-Set (%)				Fruit Size (g/fruit)				Seed No./Fruit			
	L 124		CL 5915-153		L 124		CL 5915-153		L 124		CL 5915-153	
	nat.[z]	art.	nat.	art.	nat.	art.	nat.	art.	nat.	art.	nat.	art.
ABA	2 c[y]	76 b	26 bc	77 ab	1 c	19 ab	27 b	8 b	0	3 b	10 ab	2 b
Ethrel	0 c	28 c	13 c	21 c		13 c	40 a	7 b		2 b	22 a	0 b
GA_3	80 a	100 a	75 a	92 a	6 a	13 c	13 cd	10 b	0	2 b	2 b	0 b
IAA	3 c	62 b	25 bc	69 b	6 a	12 c	32 ab	8 b	0	2 b	13 ab	0 b
Kinetin	4 c	64 b	24 bc	84 ab	4 ab	22 a	33 ab	8 b	0	14 a	14 a	1 b
IAA + GA_3 + Kinetin	25 b	80 b	30 b	78 ab	3 bc	10 c	10 d	9 b	0	0 b	10 ab	0 b
Control	12 c	77 b	40 b	92 a	7 a	15 bc	22 bc	22 a	0	3 b	13 ab	13 a
Mean	18	70	33	73	4	15	25	10	0	4	12	2

[z]Mean separation within columns by Duncan's multiple range test at the 5% level. nat. = natural pollination; art. = artificial pollination.

A natural auxin, IAA, reduced rather than enhanced fruit set rate of artificially or naturally pollinated CL 5915-153, but not L 124. This may be attributed to the high amount of IAA used. Kinetin did not show any effect on fruit set rate. Although cytokinin is known to be present in tomato flower organs, its role on fruit set and development is not clear.

Artificial pollination increased fruit set rate of both L 124 and CL 5915-153. It increased fruit size of L 124, but decreased it in CL 5915-153; the latter result may be due to the competition brought about by the high number of fruits formed by artificial pollination or less number of seeds formed in the fruit. Chemicals were applied three to two days before anthesis. They could prevent the normal processes of gamete formation and pollination, resulting in less seeds in CL 5915-153.

Kinetin tended to increase fruit size of L 124 with artificial pollination and CL 5915-153 with natural pollination. It also increased seed number of L 124 with artificial pollination. Ethrel likewise increased fruit size of CL 5915-153 with natural pollination, which may be purely due to less competition for photosynthates.

Conclusion

Artificial pollination improved fruit set of both L 124 and CL 5915-153. GA_3 also improved it in L 124 and CL 5915-153 with natural and artificial pollination. Artificial pollination or GA_3 improved fruit-set rate of CL 5915-153 without increasing seed number. It seems that pollination itself triggers fruit set; but whether this is caused by the hormonal nature of GA needs to be further investigated.

Proline Content and Its Role in Tomato Germination

Introduction

Previously we have shown that tomato anther and pistil tissues contained higher levels of proline than the leaf tissue. However, high temperature increased proline content in the leaf tissue, and decreased it in the anther and pistil tissues. This study was conducted to examine pollen germination, and proline levels in pollens obtained from tomatoes grown under low and high temperature conditions.

Materials and Methods

L 124, L 387, L 3957, L 3958, CL 1131-26, CL 1131-43, and CL 5915-153 were grown in the field under two seasons. Materials for the cool season were sown on 24 October and transplanted on 20 November 1984. Pollens were collected from 15 January to 7 February 1985. Materials for the hot season were sown on 10 May and transplanted on 5 June 1985; pollens were collected from

16 July to 6 August 1985. Flowers at anthesis were collected from the field, and pollens were removed by scraping them from the anthers in the laboratory. Pollens obtained from the same entry were bulked and stored at -15°C before being used.

During three weeks of pollen collection, the mean maximum and minimum temperatures were 23.3°C and 12.6°C for the cool season, and 31.9°C and 24.2°C for the hot season. For proline determination, there were three replications of 10 mg each for each entry. For the pollen germination test, pollens were incubated in the germination medium, without the addition of proline, at 27°C for 3 h before determining their germination rates.

Results and Discussion

In the anther tissue, pollens obtained from the cool season in general contained higher proline levels than those obtained from the hot season (Table 7). Germination rate of pollens from the cool season also was higher than that from the hot season. In the two seasons, pollen germination rate of tomato was strongly related to pollen proline content (n = 56, r = 0.78**).

Table 7. Germination and proline content of pollens obtained from tomatoes grown in the cool and hot seasons.[z]

Entry	Germination (%)			Proline (μm/g)		
	cool	hot	hot/cool (%)	cool	hot	hot/cool (%)
L 124	14.1 b	2.2 b	15 cd	207 b	103 c	50 cd
L 387	18.0 a	4.4 a	24 bc	217 a	112 b	52 cd
L 3957	18.0 a	0.8 c	5 d	166 d	103 c	62 b
L 3958	7.9 d	1.3 bc	17 cd	167 d	105 c	63 b
CL 1131-26	8.2 cd	4.3 a	55 a	162 d	78 e	48 d
CL 1131-43	10.4 c	3.7 a	35 b	180 c	96 d	54 c
CL 5915-153	4.3 e	1.5 bc	40 ab	177 c	126 a	71 a

[z]Mean separation within columns by Duncan's multiple range test at the 5% level

Pollen germinations of both CL 1131-26 and CL 5915-153 were least affected by high temperature in the hot season. Pollen proline content of the latter was also least affected by high temperature.

Conclusion

Pollen germination depended upon proline content in the pollen. Both pollen germination and pollen proline content were reduced during the hot season. The AVRDC breeding line, CL 5915-153, had the highest pollen proline content in the hot season. High proline content may confer resistance to the pollen at unfavorably high temperature.

Growth and Change of Nucleic Acids in Tomato Flowers during Cool and Hot Seasons

Introduction

It is known that high temperature reduces fruit set through several component factors during the fruit-setting process. High temperature is known to reduce pollen production, pollen viability, and pistil viability, thereby preventing successful pollination and fertilization. In order to further understand the nature of high temperature damage on pollen and pistil viability, this study investigated the growth and change of nucleic acid content in anthers and pistils during their developmental period under favorable and unfavorable growing conditions.

Materials and Methods

Materials of L 124 (TK 70), L 387 ('White Skin'), CL 1131-43, and CL 5915-153 were sown on 24 October, and transplanted on 20 November 1984. A randomized complete block design with

four replications was employed. Flower buds and/or open flowers six, four, and two days before anthesis (DBA), and at anthesis (0 DBA) were sampled on 14 January 1985. Mean maximum and minimum temperatures from field planting to sampling were 26.9°C and 17.1°C, respectively.

In a similar planting for hot season, materials of the same entries were sown on 10 June and transplanted on 11 July 1985. Flower buds of different stages as previously described were sampled on 20 August 1985. Mean maximum and minimum temperatures from field planting to sampling were 33.0°C and 24.7°C, respectively.

Sampled flower buds were counted, and the anthers and pistils removed, weighed, ground, and extracted with cold methanol for the nucleic acids. The amounts of DNA and RNA were determined by the diphenylamine and orcinol test. There were four replicates for each determination.

Results and Discussion

Both anther and pistil grew slower in the hot than in the cool season (Fig. 1). Heat-sensitive L 124 and L 387 had larger pistils than heat tolerant CL 1131-43 and CL 5915-153 in both seasons. Whether this difference in pistil size is due to the cultivars' tolerance or sensitivity needs to be confirmed.

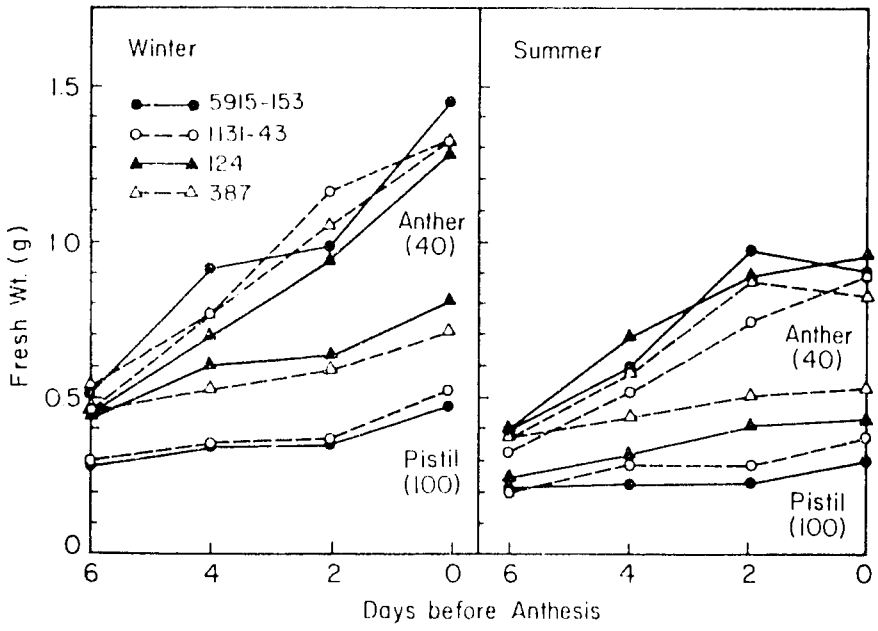

Fig.1. Fresh weight (mg) of 40 anthers and 100 pistils at different stages and seasons.

DNA contents of both anther and pistil decreased from 6 DBA to 0 DBA (lowest level) for both cool and hot seasons (Figs. 2 and 3). However, these contents, regardless of developmental stage, tended to maintain a higher level in the cool than in the hot season.

In contrast, RNA contents of pistils and especially of anthers tended to increase from 6 DBA to 0 DBA in the cool season planting (Figs. 4 and 5). These contents did not change significantly from 6 to 0 DBA in the hot season. The significance of this low RNA content in the hot season is not clear. However, the results imply that high temperature might inhibit the transcription of DNA, that is, the formation of RNA complementary to the DNA. This low RNA content may be responsible for the slow growth of anthers and pistils in the hot season.

Conclusion

High temperature in the hot season retarded anther and pistil development of both heat-tolearant and heat-sensitive tomatoes. It also tended to accelerate the decrease in anther and pistil DNA from

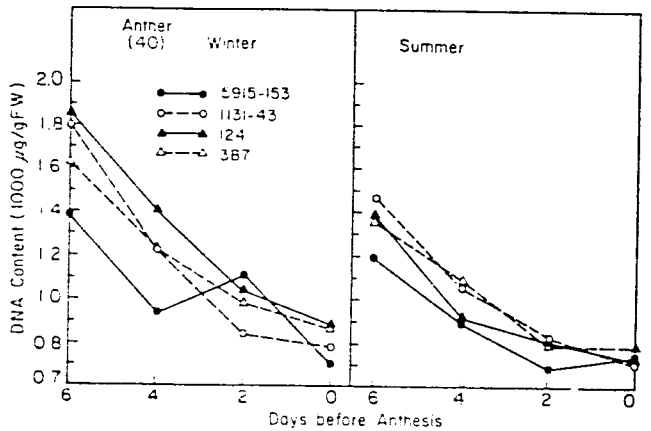

Fig. 2. DNA content in anthers of tomato flowers.

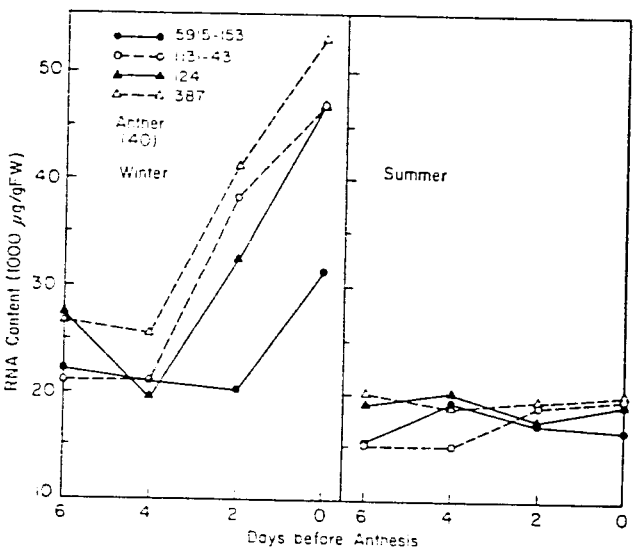

Fig. 4. RNA content in anthers of tomato flowers

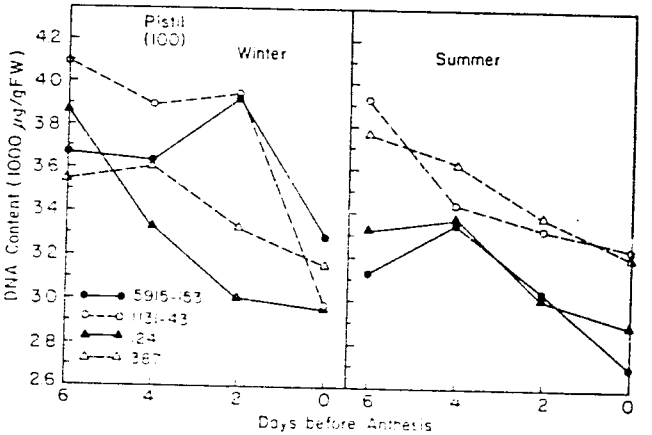

Fig. 3. DNA content in pistils of tomato flowers (mg/g F.W. pistil).

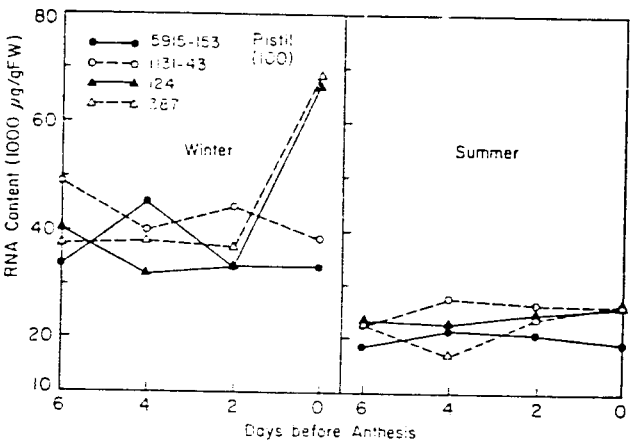

Fig. 5. RNA content in pistils of tomato flowers.

6 DBA to 0 DBA. High temperature also retarded the formation of RNA during the development of these two reproductive parts. The significance of DNA and RNA alteration and the cause of retarded flower growth at high temperature in relation to heat tolerance are far from clear.

Relation of Leaf Characterisitics to Fruit-Set and Size

Introduction

Genotypic variability in fruit-set and fruit size exists in tomato. Fruits in the same cluster generally differ in their sizes, with the larger ones developing at the proximal position. This difference in fruit growth may result from the availability of photosynthate in the nearby leaves. The present study was conducted to further assess the relation of leaf characteristics to fruit size of the different clusters of different genotypes.

Materials and Methods

Six accessions and six AVRDC breeding lines were used in this experiment. Seedlings of these entries were transplanted to the field on 16 April and 26 June 1985. The randomized complete block design was employed with four replications having 20 plants each. All plants were maintained as double stems and staked. Plants from each replicate were randomly selected and tagged for physiological observations.

Clusters 2 to 5 were used for investigating fruit set rate, fruit number, fruit weight, and seed number. Leaves positioned alternately with clusters 2 and 4 were separately harvested at three weeks after anthesis of that specific cluster. They were further divided into three groups for the determination of specific leaf weight, chlorophyll content, leaf tissue heat injury, protein content, sugar content, and starch content.

Results and Discussion

Mean maximum and minimum temperatures were higher in the June than in the April planting, resulting in low fruit set, fruit size, yield, and seed number in the former planting (Table 8). High temperature in June also resulted in low starch but high protein contents in the leaves (Table 9).

Table 8. Fruit-set, yield, and fruit size of tomatoes grown in the cool and hot seasons.[z]

Entry	Fruit-Set (%)		Yield (g/plant)		Fruit Size (g/fruit)	
	April	June	April	June	April	June
L 6	57 bc	12 e-g	553 b	107 bc	53 b	38 b-d
L 208	14 e	1 g	117 e	13 c	71 a	40 b-d
L 476	67 b	27 a-c	86 ef	27 bc	5 gh	3 g
L 1488	48 cd	17 c-f	153 e	52 bc	11 fg	8 fg
L 3690	30 e	21 b-e	8 f	4 c	1 h	1 g
L 3958	53 b-d	22 b-e	475 bc	277 a	43 cd	45 b
CL 1131-26	64 b	25 a-d	294 d	152 b	16 f	17 f
CL 1131-43	83 a	29 ab	390 cd	294 a	25 e	29 de
CL 5915-93	42 de	14 d-f	452 bc	135 bc	50 bc	41 bc
CL 5915-136	59 bc	8 fg	398 cd	45 bc	26 e	18 ef
CL 5915-153	80 a	36 a	653 a	383 a	32 e	31 cd
PI 1461	31 e	21 b-e	410 c	309 a	71 a	77 a
Mean	52	19	332	150	34	29

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.

Previously, we reported that membrane permeability may have a role in the response to high temperature. The extent of its damage by high temperature can be used as a measure of heat tolerance in tomatoes. The present study demonstrated that there was less leaf-membrane damage in the June than in the April entries (Table 10). Apparently, the process of heat acclimation at high temperature could be attributed to the low membrane damage in the June plants. Whether the increased protein content in the leaf by high temperature has any role in heat acclimation needs to be tested. The plants grown in the cooler temperature of April had higher leaf membrane damage, since they were not exposed to high temperature, thus, losing the acclimation capability.

Table 9. Comparative means for various traits of leaves positioned alternately with the 2nd and 4th clusters.

Planting	Leaf Starch (%)		SLW (mg/cm²)		Leaf Protein (%)	
	2nd	4th	2nd	4th	2nd	4th
April[z]	3.68 *	3.95 *	7.7	7.3 *	20.8 *	24.3 *
June	2.01	2.18	7.2	6.6	24.2	27.7

[z] * significant difference at the 5% level

Table 10. Characteristics of leaves positioned alternately with the 2nd cluster of tomatoes grown in the cool and hot seasons.[z]

Entry	Heat Injury (%)		Starch Content (%)	
	April	June	April	June
L 6	49 bc	5 b	3.0 cd	1.8 b
L 208	46 bc	2 c	6.0 a	2.5 b
L 476	84 a	11 a	1.8 d	1.8 b
L 1488	55 b	4 bc	2.5 d	1.6 b
L 3690	56 b	9 a	2.7 d	1.8 b
L 3958	36 b-d	4 bc	3.0 cd	1.8 b
CL 1131-26	52 bc	6 b	1.8 d	1.8 b
CL 1131-43	32 b-d	6 b	4.4 bc	1.8 b
CL 5915-93	25 cd	4 bc	3.5 cd	1.9 b
CL 5915-136	41 b-d	4 bc	6.9 a	2.2 b
CL 5915-153	15 d	4 bc	3.1 cd	1.6 b
PT 1461	45 bc	5 b	5.4 ab	3.5 a

[z] Mean separation within columns by Duncan's multiple range test at the 5% level

In terms of heat tolerance of fruit setting and fruit yield, CL 5915-153 was the best in both plantings, whereas L 208 and PT 1461 had the largest fruits in the April planting (Table 8). L 208 (Manapal) was previously reported to possess high photosynthetic potential. Since starch is the end product of photosynthetic process, it was not surprising that L 208 contained high starch content (Table 10). Significant positive correlations between fruit size and leaf starch content were found for both leaves positioned alternately with the 2nd and 4th clusters of the April entries (r = 0.397 ** and 0.422 ** for the 2nd and 4th clusters, respectively).

On the other hand, among the June plants PT 1461 still maintained the largest fruit. Fruit size of L 208 decreased at high temperature, although both PT 1461 and L 208 still contained high starch content in the leaf. Significant positive correlations between fruit size and leaf starch content were also found for both leaves positioned alternately with the 2nd and 4th leaves of the June entries (r = 0.422 ** and 0.536 ***, respectively). L 476 and L 3690 had the smallest fruit size, as well as highest leaf heat injury.

Conclusion

An AVRDC breeding line, CL 5915-153, is the most heat-tolerant entry. However, another AVRDC breeding line, PT 1461, and accession L 208 had the largest fruits. Both PT 1461 and

L 208 maintained high starch content in the leaf, which may act as an important source factor for the dry-matter accumulation in the alternately positioned, fruiting cluster. Since it was previously demonstrated that L 208 possesses high-photosynthetic potential, the results suggest that fruit size may be strongly related to the photosynthetic activity of the nearby leaf.

Effect of Controlled Growth Pattern on Tomato Fruit-Set at High Temperature

Introduction

The growth patterns of determinate and indeterminate tomatoes are quite different. The determinate stem develops a single leaf node and a single inflorescence per segment and terminates with an inflorescence; this results in less thriving leaf growth than in the indeterminate tomato. On the other hand, the terminal bud of an indeterminate tomato does not set fruit; it always produced leaves and more stems from the growing point, and usually has the normal three leaf nodes and single inflorescence per stem segment.

Since most of the heat tolerant tomatoes belong to the determinate type, it is suspected that there might be a relationship between growth pattern and fruit-set at high temperature. By defoliating the indeterminate tomato to imitate the determinate tomato, and topping the determinate tomato with a terminal inflorescence to mimic the indeterminate tomato, the present experiment attempted to test the hypothesis.

Materials and Methods

Seedlings of L 387 (indeterminate), CL 5915-206D$_1$ 2-2-0 (semi-indeterminate), and CL 5915-153D$_1$-3-3 (determinate) were transplanted to clay pots (ID 20 cm) on 2 July 1985. Plant growth pattern was controlled by defoliation and/or topping of the terminal bud. The following treatments were given:

1. CL 5915-153: without removing the leaves and terminal inflorescence to maintain its original determinate characteristic.
2. CL 5915-153: removing the terminal inflorescence and encouraging the second axillary bud from the top to take over in order to mimic the indeterminate growth pattern of L 387 and CL 5915-206.
3. L 387: without removing the leaves to maintain its original indeterminate characteristic.
4. L 387: removing the leaves to maintain a single leaf node and a single inflorescence per stem segment in order to mimic the determinate growth pattern of CL 5915-153.
5. CL 5915-206: without removing the leaves to maintain its original semi-indeterminate characteristic.
6. CL 5915-206: removing the leaves to maintain a single leaf node and single inflorescence per stem segment in order to mimic the determinate growth pattern of CL 5915-153.

There were four replicates, each with four plants, for each treatment. On 29 October 1985 plants were harvested and growth parameters measured. Mean maximum and minimum temperatures from transplanting to harvesting were 34.5 °C and 30.0 °C, respectively.

Results and Discussion

Both CL 5915-153 without topping and CL 5915-206 without defoliation produced more fresh weight and yield than the control, L 387 (Table 11). Defoliation of CL 5915-206 and topping of CL 5915-153 did not alter total fresh weight and fruit yield, except that topping increased fruit set rate of CL 5915-153. Defoliation reduced total fresh weight of L 387; however, it increased flower number, fruit-set, fruit number, and yield.

Table 11. Effect of controlled growth on vegetative and reproductive growth and on yield of tomatoes.[z]

Entry	Treatment	Total Fresh Wt (g/plant)	Yield (g/plant)	HI (%)	Flower No./ Plant	Fruit-Set (%)	Fruit No./Plant	Fruit Size (g/plant)
L 387	control	720 b	24 c	3 c	201 b	2 e	3 d	7 c
	defoliation	700 b	144 b	21 b	242 a	7 d	18 c	8 bc
CL 5915 -153	control	980 a	556 a	57 a	122 cd	45 b	54 a	10 b
	topping	979 a	533 a	55 a	107 d	52 a	55 a	10 b
CL 5915 -206	control	947 a	535 a	57 a	129 cd	24 c	31 b	17 a
	defoliation	914 a	561 a	61 a	138 c	22 c	30 b	19 a

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.

Conclusion

Providing heat-sensitive, indeterminate L 387 with the single leaf node and single inflorescence per segment of main stem to mimic the determinate tomato resulted in higher fruit-set and fruit yield than the control. The results imply that the thriving leaf growth due to high leaf number per stem segment in the indeterminate tomato may play a dominant role in inflorescence development at high temperature, thereby reducing fruit-set. In the determinate tomato, developing fewer leaves per segment and terminating with an inflorescence may facilitate the translocation of photosynthates for reproductive growth.

Effect of Leaf and Flower Removal on Fruit-Set and Growth of Tomato

Introduction

There is a usual competition of assimilates between vegetative and reproductive growth during the life cycle of the tomato plant. It was shown earlier that the inhibition of vegetative growth by growth retardants also promoted flowering and prevented flower abortion. It is suspected that the nutrient balance may be disrupted by high temperature which subsequently reduces fruit-set and fruit growth. This experiment was conducted to investigate the effect of leaf and/or flower removal, which alters growth competition, on fruit set and fruit growth at high temperature.

Materials and Methods

L 387 and CL 5915-206 were sown and transplanted to clay pots (ID 20 cm) on 5 June and 1 July 1985, respectively. Plants were given four different treatments: 1) control; 2) new leaves positioned alternately with the flower clusters were removed; 3) developing flower buds after the third flower of each cluster were removed; and 4) treatments 3 and 4 were combined. Growth parameters, fruit-set, and fruit size were investigated on 11 September 1985.

Results and Conclusion

Flower and/or leaf removal did not influence fruit-set and yield of both L 387 and CL 5915-206 (Table 12). However, they apparently increased fruit size of CL 5915-206. The results seem to imply that growth competition may not play a role in fruit-set rate at high temperature; however, it may control fruit size.

Table 12. Effect of leaf and/or flower removal on fruit-set, fruit size, and yield of tomato.

Treatment	Fruit-Set (%)		Fruit Size (g/fruit)[z]		Yield (g/plant)		HI (% fresh wt)[z]	
	387	5915-206	387	5915-206	387	5915-206	387	5915-206
Control	0.3	15.9	7 b	14 b	2	214	0	36 a
Leaves removed	0.9	16.4	14 ab	17 ab	10	218	2	41 a
Flowers removed	1.6	20.5	16 a	20 a	17	183	4	32 ab
Leaves + flowers removed	1.0	16.a	18 a	20 a	5	138	1	26 b

[z]Mean separation within columns by Duncan's multiple range test at the 5% level.

Water Consumption of Tomato

Introduction

More than 80% of tomato fresh weight is water. However, there is no information on how the water is taken up and consumed during the whole growing period. The present study investigated the water uptake, consumption pattern, and water use efficiency of tomato during the cool season by using the PVF system.

Materials and Methods

Seeds of CL 1131-43 and CL 5915-153 were first sown in seedling flats on 24 October 1984. The seedlings were grown in the greenhouse and later transplanted to wooden boxes with a sand-and-soil mixture on 26 November 1984. The wooden box set up was previously described for Chinese cabbage. A PVF strip was laid at the bottom of the growth medium and extended from the wooden box to a container with water. The weekly consumption of water by the plant was recorded. Plants were maintained without pruning. The final observation harvest was done on 19 March 1985.

Results and Discussion

Both CL 1131-43 and CL 5915-153 had good yields when grown in the PVF system in the cool season (Table 13). The latter had higher yields, average fruit size, and total fresh and dry weights than the former. During the 113 days of growth in the wooden box, the total water consumption of CL 1131-43 was higher than that of CL 5915-153. This was probably due to the larger leaf area of CL 1131-43, although the water that transpired per unit leaf area was higher in CL 5915-153 than in CL 1131-43. In terms of water use efficiency, CL 1131-43 required more water than CL 5915-153 to produce a unit of dry matter during the whole growing period.

Data in Fig. 6 show that the water uptake was slow right after transplanting, but started to accelerate five days after transplanting. The maximum average water uptake occurred 25 to 55 days after transplanting. The average water uptake started to decline at harvest time.

Conclusion

CL 1131-43 and CL 5915-153 utilized more than 40 liters/plant of water during the 113-day growth period in the cool season. Although CL 5915-153 transpired more water per unit leaf area, it was more effective in dry matter production. Maximum water uptake occurred in the middle of the flowering and fruiting period. The study of tomato water consumption during high temperature is still in progress.

Table 13. Growth, yield, and water consumption of tomato under favorable cool conditions.

Parameter	CL 1131-43	CL 5915-153
Fruit yield (g/plant)	1073	1296
Fruit no./plant	54	55
Fruit size (g/fruit)	75	88
Leaf area (dm^2/plant)	28	21
Water used (l/plant)	40	37
Total fresh weight (g/plant)	1348	1595
Total dry weight (g/plant)	125	135
Water use efficiency (ml/g dry wt.)	323	276
Water transpired (ml/cm^2)	14.2	17.7

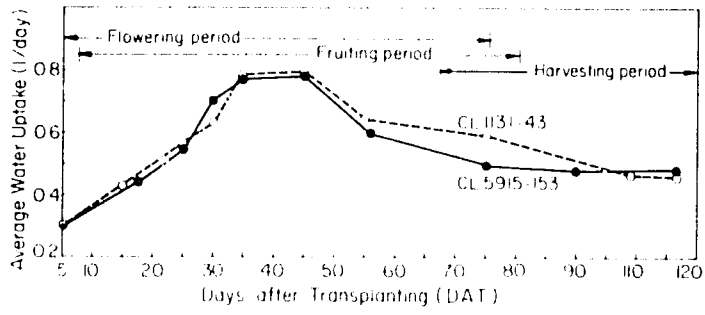

Fig. 6. Average water uptake of tomatoes in the cool season.

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Legume Crops Program

Mungbean Breeding

Hybridization Program

Hybridization among diverse genotypes is very important to create genetic variability and select genotypes with both high yield and disease resistance. The 28th crossing block planted in spring 1985 had 23 breeding lines and one accession (V 3726, Varsha); while the 29th crossing block planted in summer consisted of 21 breeding lines and one accession (V 5000, Shanhua 1). As in the past the emphasis was to combine high yield, synchronized maturity, and resistance to diseases.

With the objective of enhancing resistance to *Cercospora* leaf spot (CLS) and powdery mildew (PM) and improving the synchronized maturity of the AVRDC selections, 159 crosses were made.

Hybrid and segregating populations derived from these crosses will be screened for high yield, uniform maturity, and disease resistance.

Interspecific Hybridization

Introduction

The close relatives of mungbean, *Vigna mungo* and *Vigna radiata* subspp. *sublobata* are good sources of pest resistance and improved nutritional quality, particularly in methionine content. Therefore, the methionine level of mungbean cultivar can probably be increased by introducing genes from these plants.

Materials and Methods

A. Two mungbean and two black gram lines were crossed in all combinations. Among the four F1 hybrids (IVC 2001, IVC 2002, IVC 2003, and IVC 2004), only IVC 2003 produced flowers and F2 seeds. Backcrosses to both parents IVC 2003 were also obtained in fall 1985. After screening for high methionine content, the selected F2 plants will be backcrossed to mungbean.

B. Because of the low hybrid fertility in single crosses, the following double crosses were carried out. Nine mungbean lines and four black gram lines were selected for interspecific hybridization through double crosses. In spring, single crosses of mungbean x mungbean and black gram x black gram were made. Among these single crosses, five double crosses between mungbean and black gram were obtained in fall. The double crossed F1 seeds will be planted in spring 1986, and the F2 populations will be screened for higher methionine content.

C. Two mungbean lines (var. *radiata*) with resistance to CLS and four lines (subspp. *sublobata*) with higher methionine content were crossed in spring 1985. Backcrosses and F2 populations were generated in fall 1985. A list of the lines used in this crossing program is given in Table 1.

Results and Discussion

The mean values of alcohol soluble and total methionine content of parental lines and their hybrids are shown in Fig. 1. The mean alcohol soluble methionine levels of F1 hybrids, backcrosses, and F2

Table 1. Parental lines used in interspecific hybridization.

A. Single crosses between mungbean and black gram
Mungbean: V 2184, V 3476
Black gram: VM 2156, VM 2164
B. Double crosses between mungbean and black gram
Mungbean: V 1148, V 1198, V 1380, V 1410, V 1944, V 1950, V 1955, V 1980, V 2773
Black gram: VM 3115, VM 3117, VM 3122, VM 3125
C. Crosses between var. *radiata* x var. *sublobata*
Mungbean: VC 3689-1-1-B-1, VC 1560-D
sublobata: TC 2208, TC 2209, TC 2210, TC 2211

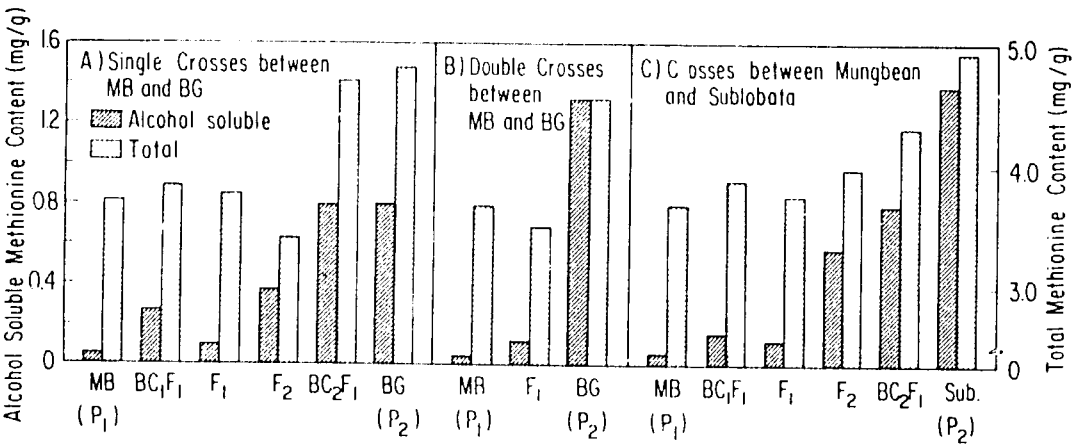

Fig. 1. Mean methionine content of mungbean (*Vigna radiata*), black gram (*Vigna mungo*), *sublobata* (*Vigna radiata* subspp. *sublobata*), and their hybrids and segregating populations.

populations were significantly increased. However, total methionine content of these populations increased only in the *radiata* x *sublobata* crosses. Furthermore, success of crossing was higher in *radiata* x *sublobata* than in the other two crosses.

Conclusion

Methionine level of mungbean cultivars can be successfully increased by crossing especially with *sublobata* genotypes. These results indicated that the inheritance of methionine content appeared to be controlled by polygenes. Therefore, each segregating population should be screened for higher methionine content before backcrossing with mungbean.

Genetics of Leaflet Type and Hypocotyl Color of Mungbean

Introduction

Mungbean plants generally have a relatively close canopy compared to the other grain legume species. The large amount of self-shading of the leaf canopy may probably reduce seed yield because of low light penetration. A modification of the leaflet type may influence the leaf canopy and probably increase seed yield. Before initiating a breeding program to incorporate a modified leaf type, the inheritance of this character should be studied.

Materials and Methods

Two mungbean parental lines with different leaflet type and hypocotyl color were crossed: P1 (VC 1973 A), a cultivated line with normal leaflet and green hypocotyl; P2 (V5 926), a mutant with multiple leaflets and purple hypocotyl.

A total of 1,536 F2 seeds of VC 1973 A x V 5926 were planted on 22 July 1985. Seeds were dibbled in rows spaced 50 cm apart and 30 cm between single-plant hills. The suggested AVRDC cultural practices were followed. Data on leaflet shape and hypocotyl color were collected in the seedling stages of both F1 and F2 populations. In addition, single plant observations were made on F2 for days to flowering, plant height, branches per plant, pods per plant, seeds per pod, 100 seed weight, and seed yield per plant. F3 seeds of individual F2 plants were grown in the greenhouse, and the nine different genotypes were identified based on segregation of leaflet type and hypocotyl color.

Results and Discussion

Hypocotyl color and leaflet type were independently controlled by two major genes A and B, with normal leaflets (B-) and purple hypocotyl (A-) completely dominant to mutant leaflet (bb) and green hypocotyl (aa). With these two index genes, F2 plants were identified and sorted into nine groups, AABB, AABb, AAbb, AaBB, AaBb, Aabb, aaBB, aaBb, and aabb (Fig. 2). The mean data of these nine F2 genotypes for yield characters are shown in Table 2. The effect of hypocotyl color on mungbean yield was not significant, but the leaflet type showed positive influence on yield and yield components, such as branches per plant and pods per plant. Genotypes with normal leaflets (B-) produced significantly larger seed yield and more branches and pods per plant than the multiple leaflet genotypes (bb) in the F2 population. However plant height, seeds per pod, and 100 seed weight were not associated with the leaflet type in the F2 population.

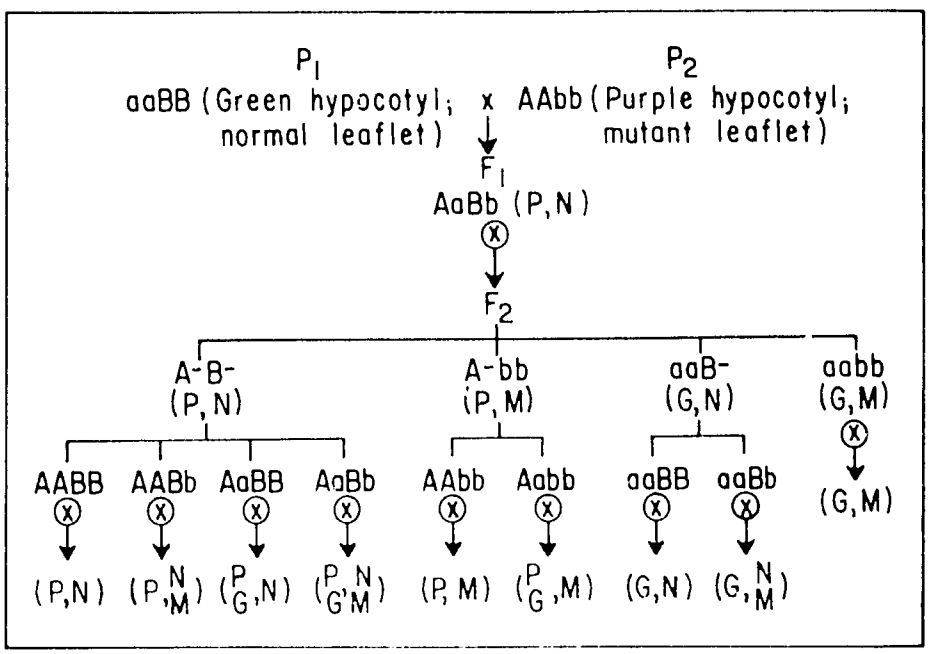

Fig. 2. The segregation of two independent major genes - A and B.

Table 2. Yield component means for the F2 population of a cross between normal x multiple leaflet.

Genotype	Yield/ Plant (g)	Days to Flowering	Plant Height (cm)	Pods/Plant	Seeds/Pod	Branches/ Plant	100-Seed Wt (g)
Normal leaflet							
AABb	26.24 ± 1.52	44.59 ± 0.51	77.05 ± 1.62	44.02 ± 2.44	13.00 ± 0.10	5.46 ± 0.22	5.71 ± 0.06
AABb	25.64 ± 1.00	45.77 ± 0.35	78.90 ± 1.17	43.39 ± 1.66	12.67 ± 0.13	5.20 ± 0.16	5.65 ± 0.05
AaBB	24.19 ± 0.83	44.99 ± 0.39	74.78 ± 1.10	41.70 ± 1.31	12.75 ± 0.08	4.97 ± 0.15	5.56 ± 0.05
AaBb	25.54 ± 0.80	45.44 ± 0.26	77.00 ± 0.88	41.96 ± 1.09	12.89 ± 0.05	5.00 ± 0.11	5.68 ± 0.03
aaBB	23.97 ± 1.07	44.93 ± 0.45	76.32 ± 1.61	41.14 ± 1.73	12.91 ± 0.11	4.89 ± 0.19	5.58 ± 0.06
aaBb	24.31 ± 1.08	44.62 ± 0.42	75.73 ± 1.42	40.67 ± 1.77	12.86 ± 0.10	4.70 ± 0.17	5.73 ± 0.06
Multiple leaflet							
Aabb	20.93 ± 0.79	46.40 ± 0.40	76.05 ± 1.21	35.41 ± 1.38	12.71 ± 0.11	4.57 ± 0.14	5.73 ± 0.05
AaBb	18.16 ± 1.02	46.06 ± 0.58	72.45 ± 2.23	30.20 ± 2.03	12.67 ± 0.14	4.18 ± 0.26	5.72 ± 0.09
aabb	19.69 ± 1.13	46.05 ± 0.49	75.74 ± 2.11	32.34 ± 1.86	12.91 ± 0.11	4.42 ± 0.22	5.68 ± 0.08

Conclusion

These results indicated that the leaflet type of mungbean may probably have a direct influence on seed yield components. To verify this hypothesis, production of mungbean isolines with different leaflet types and a long-term evaluation in the field are necessary.

Yield Trials

Introduction

Outstanding breeding selections are evaluated through different levels of yield trials in different seasons. In addition to yield, the selections are also evaluated for disease resistance and photoperiod sensitivity.

Materials and Methods

The series of yield trials conducted in 1985 were the International Mungbean Nursery (IMN), elite yield trial (EYT), advanced yield trial (AYT), intermediate yield trial (IYT), preliminary yield trials (PYTs) and evaluation of released lines (RE). The details of the trials are given in Table 3. The first harvest of the fall plantings was carried out in late December, 1985, therefore, the reported yield will be incomplete without the fall 1985 data.

Results and Discussion

IMN. Average yield of 20 IMN entries consisting of six cultivars from different countries and 14 AVRDC breeding lines was 1.1 t/ha in spring and 1.90 t/ha in summer. Nine AVRDC breeding lines outyielded the highest yielding cultivar (V 2984 - KJ #5) and the conventional check cultivar (V 3476 - Pag asa 1) which yielded an average of 1.34 t/ha and 1.23 t/ha, respectively in summer (Table 4). However, the yield differences in spring was not statistically significant. The highest yield of 2.31 t/ha was produced by VC 2768 A in summer. High yielding AVRDC breeding lines shown better disease resistance and larger seed size than the check and national cultivars.

EYT. Average yield of 20 EYT entries was 1.21 t/ha in spring and 1.78 t/ha in summer. Nine breeding lines significantly yielded more than the check cultivar in summer; however, in spring only breeding line VC 3012 A outyielded the check significantly (Table 5). Except line VC 2917 A for PM, all other breeding lines had a moderate level of resistance to both CLS and PM than the check. None of the breeding lines showed a better synchronized maturity than the check. It appears that lines possessing moderate levels of resistance to diseases are more vigorous than the susceptible lines,

Table 3. Mungbean yield trials conducted during 1985, AVRDC.

Type of Trial[z]	No. of Entries[y]	Sowing Date	Harvested Date 1st	2nd	3rd	Plot Size (m^2)	Experim. Design	No. of Reps
Spring Planting								
IMN	20	3/6	5/17	6/3	6/24	18	RCBD[x]	3
EYT	20 (2)	3/6	5/17	6/3	6/24	18	RCBD	5
AYT	16 (1)	3/6	5/23	6/5	6/24	12	RCBD	4
IYT	64 (1)	3/6	5/22	6/4	6/25	6	Lattice	3
PYT-I	49 (1)	3/12	5/23	6/4	6/24	6	Lattice	3
PYT-II	81 (1)	3/7	5/22	6/4	6/25	6	Lattice	3
RE	10 (1)	3/7	5/21	6/4	6/24	11	RCBD	4
Summer Planting								
IMN	20	7/18	10/7	11/5		18	RCBD	3
EYT	20 (2)	7/13	9/12	10/14		18	RCBD	5
AYT	16 (1)	7/12	9/12	10/14		12	RCBD	4
IYT	64 (1)	7/16	9/19	10/18		6	Lattice	3
PYT-I	49 (1)	7/15	9/24	11/5		6	Lattice	3
PYT-II	81 (1)	7/13	9/16	10/16		6	Lattice	3
PYT-III	81 (1)	7/13	9/13	10/15		6	Lattice	3
RE	10 (1)	7/19	9/26	11/6		12	RCBD	4
Fall Planting								
IMN	20	10/3	12/27			18	RCBD	3
EYT	20 (2)	10/3	12/26			18	RCBD	5
AYT	16 (1)	10/3	12/26			12	RCBD	4
IYT	64 (1)	10/4				6	Lattice	3
PYT-I	49 (1)	10/4				6	Lattice	3
PYT-II	81 (1)	10/4	1/7			6	Lattice	3
PYT-III	81 (1)	10/4	12/30			6	Lattice	3
RE	12 (1)	10/3				6	RCBD	4

[z]IMN = international mungbean nursery, EYT = elite yield trial, AYT = advanced yield trial, IYT = intermediate yield trial, PYT = preliminary yield trial, RE = evaluation of released lines. [y]Number in parenthesis = number of checks: V 3476 and V 3726 in EYT, V 3476 in AYT, IYT, and PYT's and VC 1560 D in RE. [x]Randomized complete block design.

Table 4. High-yielding lines from the 13th IMN in spring and summer 1985, AVRDC.

AVRDC No.	Parentage or Variety Name	Yield (t/ha) sp	su	mean	% 1st Harvest[z]	Disease[y] CLS	PM	1000-Seed Wt (g)
VC 2771 A	VC 1560 D/MG 50 10A(G)	1.14	2.29	1.72	75	MR	MR	60
VC 2768 A	VC 1482 A/VC 1628 A	1.12	2.31	1.71	82	MR	MS	59
VC 2750 A[x]	VC 1168 B/VC 1560 A	1.33	2.08	1.71	77	MR	MR	52
VC 2754 A	VC 1177 B/VC 1560 B	1.07	2.29	1.68	78	MR	MR	64
VC 2768 B	VC 1482 A/VC 1628 A	1.08	2.16	1.62	81	MS	MS	60
VC 1482 E	EG MG 6D/ML 3	1.00	2.22	1.61	76	MR	MR	50
VC 2764 A	VC 1481 A/VC 1628 A	1.16	2.05	1.60	81	MS	MS	58
VC 3061 A[x,w]	VC 1574 A/VC 1973 A	1.13	2.06	1.60	86	MR	MR	56
VC 2764 B	VC 1481 A/VC 1628 A	1.03	2.15	1.60	76	MR	MS	57
V 2984 (Ck)	KI #5	1.10	1.58	1.34	98	MS	VS	42
V 3476 (Ck)	Pag asa 1	0.89	1.57	1.23	88	VS	VS	48
Mean of 20 entries		1.00	1.90	1.45	83.0			55.0
CV (%)		20.60	9.60	13.40	7.7			3.6
LSD (.05)		0.34	0.30	0.22	7.3			2.3

[z]Expressed as a percentage of total yield, average of two seasons. [y]CLS = Cercospora leaf spot, PM = powdery mildew. CLS was rated in summer and fall, and PM in spring and fall in the disease nurseries. MR = moderately resistant, MS = moderately susceptible, VS = very susceptible. [x]Dull seed coat.
[w] Photoperiod insensitive.

which prolongs plant growth and reduces uniform maturity. Seed size of the high-yielding breeding lines were fairly large and ranged between 44-59 g/1000 seeds. Among the high-yielding breeding lines, VC 2917 A appeared to be photoperiod-insensitive.

AYT. Average yield of 16 AYT entries was 0.97 t/ha in spring and 1.87 t/ha in summer (Table 5). Twelve breeding lines outyielded the check cultivar V 3476 only in the summer. The observed

Table 5. Performance of high-yielding lines from the elite, advanced, and intermediate yield trials in spring and summer 1985, AVRDC.

AVRDC No.	Yield (t/ha)			% 1st Harvest		Disease[z]		P-S[y]	1000-Seed Wt (g)
	sp	su	mean	sp	su	CLS	PM		
A. Elite trial									
VC 3012 A[x]	1.86	1.94	1.89	52	41	MR	MR	25	44
VC 3012 B[x]	1.42	1.95	1.69	85	43	HR	MR	11	44
VC 3301 A[x]	1.51	1.86	1.68	74	42	MR	MR	5	45
VC 3178 A	1.38	1.95	1.67	69	34	MR	MR	10	53
VC 2917 A	1.56	1.70	1.63	80	38	MR	MS	2	47
VC 2802 A	1.16	2.09	1.62	88	43	MR	MR	7	51
VC 3004 A[x]	1.42	1.80	1.61	76	40	MR	MR	14	52
VC 2762 A[x]	1.27	1.87	1.57	68	30	MR	MR	18	56
VC 3011 A	1.11	1.99	1.55	90	36	MR	HR	6	59
V 3476 (Ck)	1.23	1.33	1.28	89	63	VS	VS	11	48
Mean of 20 entries	1.21	1.78	1.50	80	44				51
CV (%)	26.0	12.2	18.1	11.5	16.6				5.9
LSD (.05)	0.40	0.27	0.24	11.6	9.1				2.6
B. Advanced trial									
VC 3116-28-2B-2-B	1.16	1.97	1.57	57[v]		MS	MS	1	57
VC 3580-1-2-2-1-B[w]	1.13	1.94	1.54	55		MS	MR	5	51
VC 3541-2B-5-B-1-B[w]	1.00	2.03	1.51	51		MS	MR	3	64
VC 3664-B-2-B-1-B[w]	.97	2.04	1.51	56		MR	MR	7	57
VC 3513-2B-7-B-1-B	1.13	1.85	1.49	51		MR	MR	8	61
VC 3519-1-3-1-1-B	1.09	1.89	1.49	61		MS	HR	5	60
VC 3762-1-B-2-1-B	0.93	2.03	1.48	50		MR	MS	3	52
VC 3737-1-2-1-2-B	1.05	1.90	1.47	59		MR	MR	0	58
VC 3751-3-B-2-2-B	1.08	1.86	1.47	56		MR	HR	0	51
VC 3528-2B-3-B-2-B[w]	0.91	2.02	1.46	55		HR	HR	3	60
VC 3300-2B-2-1-B	0.97	1.82	1.40	66		MS	MS	3	62
VC 3687-B-1-B-1-B	0.86	1.91	1.38	64		HR	MS	4	61
V 3476 (Ck)[w]	0.69	1.47	1.08	70		VS	VS	11	50
Mean of 16 entries	0.97	1.87	1.42	58					56
CV (%)	35.3	9.61	19.2	14.9					4.2
LSD (.05)	0.49	0.26	0.27	8.6					2.4
C. Intermediate trial									
VC 3658-B-3-B-3-B	1.11	2.57	1.84	76[v]		MR	MR	6	55
VC 3751-1-B-2-2-B	1.10	2.50	1.80	72		MS	MR	2	63
VC 3738-3B-2-B	1.28	2.25	1.77	84		MS	MR	3	56
VC 3543-B-2-1-1-B	0.87	2.65	1.76	68		HR	HR	3	58
VC 3678-B-1-B-1-B	1.12	2.35	1.74	70		MS	MS	1	54
V 3476 (Ck)[w]	0.73	1.98	1.35	79		VS	VS	11	52
Mean of 64 entries	0.96	2.12	1.54	70					57
CV (%)	18.0	9.2	12.6	11.4					3.3
LSD (.05)	0.28	0.31	0.22	9.1					2.1

[z]CLS = Cercospora leaf spot; PM = powdery mildew; MR = moderately resistant; HR = highly resistant; VS = very susceptible. [y]P-S = photoperiod-sensitivity; differences in flowering date between normal and extended photoperiods in fall 1985. [x]Dull seed coat. [w]Shiny seed coat. [v]Mean value of two seasons.

yield differences in spring were not statistically significant. Although the check cultivar was the lowest yielder in summer, the total yield percentage at first harvest was highest. Furthermore, the high-yielding lines also had a bigger seed size and were less sensitive to the changes in photoperiod.

IYT. Twenty-four breeding lines significantly outyielded the check cultivar V 3476 in summer. The top five breeding lines produced an average yield of over 1.70 t/ha (Table 5). All the five lines (except VC 3658-B-3-B-3-B) had larger seed size than V 3476 and are less sensitive to photoperiod. Breeding lines with resistance to both CLS and PM and with significantly higher yields than V 3476 are also listed in Table 5.

PYT. In the PYT-I trial 27 breeding lines significantly outyielded the check cultivar V 3476, and seven lines had better yield in both spring or summer (Table 6). Two had moderate resistance to both CLS and PM. However, none of the high-yielding lines showed better synchronized maturity than the check.

Table 6. High-yielding lines selected from preliminary yield trials I and II, AVRDC 1985.

AVRDC No.	Yield (t/ha) sp	su	mean	% 1st Harvest	Disease[z] CLS	PM	1000-Seed Wt (g)
PYT-I							
VC 3849-2B-1-1-B	1.72	2.09	1.90	62	HR	MS	57
VC 3853-2B-2-1-B[y]	1.83	1.96	1.90	58	MR	MS	56
VC 3857-2B-2-1-B[y]	1.63	2.13	1.88	58	MR	MS	57
VC 3821-B-2-1-1-B	1.51	2.16	1.84	57	MS	MR	66
VC 3827-2B-2-1-B	1.60	2.03	1.81	65	MS	MS	64
VC 3845-2B-3-1-B	1.51	2.02	1.77	53	MR	MR	44
VC 3812-2B-4-1-B	1.46	2.05	1.76	59	HR	MR	54
V 3476 (Ck)	1.20	1.71	1.45	72	VS	VS	53
Mean of 81 entries	1.42	1.83	1.63	63			57
CV (%)	9.0	9.4	9.4	11.2			3.4
LSD (.05)	0.21	0.28	0.17	8.0			2.2
PYT II							
VC 3890-2B-1-1-B[y]	1.37	2.55	1.96	67	MS	MR	60
VC 3890-B-2-1-1-B[y]	1.43	2.34	1.88	55	MR	MS	67
VC 3888-2B-4-1-B[y]	1.42	2.14	1.78	62	MR	MR	62
VC 3903-B-3-1-1-B	1.24	2.31	1.77	61	MR	MS	63
VC 3907-B-2-1-1-B[y]	1.28	2.26	1.77	61	VS	MS	61
VC 3885-2B-2-1-B[y]	1.30	2.22	1.76	59	MS	MS	63
V 3476 (Ck)	0.82	1.56	1.19	73	VS	VS	50
Mean of 81 entries	1.03	1.76	1.40	62			58
CV (%)	18.5	13.9	16.8	16.0			5.5
LSD (.05)	0.31	0.39	0.27	11.2			3.6

[z]CLS Cercospora leaf spot, PM powdery mildew, MR moderately resistant; MS moderately susceptible; HR highly resistant, VS very susceptible, [y]Dull seed coat.

In the PYT-II, 21 breeding lines significantly outyielded the check V 3476 either in spring or in summer. Entries with average yields of over 1.75 t/ha and which yielded more than the check in both seasons are presented in Table 6. These six breeding lines also had larger seed size than the check, and one showed moderate resistance to both CLS and PM. The total yield percentage at first harvest was not statistically different from the check in two of the six high yielding lines.

Among the 81 entries evaluated in PYT-III in the summer season, only 12 breeding lines significantly outyielded V 3476 (Table 7). The total yield percentage at first harvest was not statistically

Table 7. High-yielding lines from preliminary yield trial III in summer 1985, AVRDC.

AVRDC No.	Yield (t/ha)	% 1st Harvest	Disease[z]		1000-Seed Wt (g)
			CLS	PM	
VC 3918-2B-3-2-1-B	2.58	41	MS	VS	59
VC 3860-B-1-1-2-1-B	2.55	43	MR	MS	61
VC 3928-B-2-1-1-1-B	2.51	50	MR	MS	51
VC 3919-2B-3-1-1-B	2.43	55	MR	VS	55
VC 3889-B-2-1-2-1-B	2.39	44	MS	MS	52
VC 3891-B-2-1-1-1-B	2.39	47	MS	MS	51
VC 3888-B-2-2-2-1-B	2.35	47	MS	MS	62
VC 3888-B-6-1-1-2-B	2.34	49	MR	MS	65
VC 3860-B-5-1-1-1-B	2.32	47	MS	MS	59
VC 3904-B-1-1-1-1-B	2.30	48	VS	MS	55
VC 3870-B-5-1-1-1-B	2.29	57	MS	MR	47
VC 3898-2B-1-2-1-B	2.29	48	MS	MR	61
V 3476 (Ck)	1.79	64	VS	VS	46
Mean of 81 entries	1.93	48			52
CV (%)	12.3	11.6			3.2
LSD (.05)	0.38	8.9			2.7

[z]CLS = Cercospora leaf spot; PM = powdery mildew; MR = moderately resistant; MS = moderately susceptible; HR = highly resistant; VS = very susceptible.

different from the check in two of these lines. In all these trials, the spring crop showed a better synchronized maturity than that of summer.

RE. Sixteen AVRDC mungbean lines have been released in 11 countries until the end of 1985 (Table 8). We selected nine of them for yield re-evaluation.

Table 8. List of AVRDC mungbean releases, December 1985.

Local Name	AVRDC ID No.	Year	Country	Characteristics[z]
ASVEG '78	VC 1089-A	1978	Costa Rica	HY
Bangasa	V 3476	1980	Korea	HY,UM,LD
Tainan (Sel.) #3	VC 1628-A	1981	Taiwan	HY,UM,LD
King	V 1388	1982	Australia	HY,EM,PW,LD
Station 46	VC 1000-D	1982	Fiji	HY
Manyar	VC 1089-A	1982	Indonesia	HY,CLS,R
Nuri	V 2773	1982	Indonesia	HY,(CLS),R
Shanhua	VC 1973-A	1982	Korea	HY,MMV,PM,(CLS),UM
Type 77	VC 1131-B	1982	Sri Lanka	HY,MYMV,CR
Pusa 105	VC 1137-A	1983	India	HY,MYMV,CLS,PM
Imara	V 1380	1983	Tanzania	HY
Station 25	VC 1007-A	1984	Fiji	HY
Station 27	VC 1160-B	1984	Fiji	HY
BPI-MG 2	VC 1163-D	1984	Philippines	HY,EM,UM,LD
Gelatik	VC 1160-22-2B-1-B	1985	Indonesia	HY
Walet	VC 1163-A	1985	Indonesia	HY
Boliche 451	VC 1163	1985	Ecuador	HY

[z]HY = high grain yields; UM = uniform maturity; LD = resistant to lodging; EM = early maturity; PW = resistant to pod weathering; CLS = resistant to Cercospora leaf spot; ( ) = indicates moderately resistant; R = resistant to rust; MMV = resistant to mungbean mottle virus; PM = resistant to powdery mildew; MYMV = resistant to mungbean yellow mosaic virus; CR = resistant to charcoal rot.

Three cultivars, Bangasa, Shanhua, and Nuri outyielded the check in the spring (Table 9). However in summer, six of the nine cultivars yielded more than the check. The seed size of cv. King was significantly larger than that of the check. Better synchronized maturity was also noticed in the six cultivars.

As with last year in all the yield trials (except in RE) conducted in summer, number of pods per plant had a highly significant correlation with yield, regardless of planting season (r varied from 0.27** to 0.82**).

Table 9. Performance of released mungbean lines in spring and summer 1985, AVRDC.

AVRDC No.	Local Name	Yield (t/ha)			% 1st	Disease[z]		1000-Seed
		sp	su	mean	Harvest	CLS	PM	Wt (g)
V 3476	Bangasa	1.74	2.35	2.05	79	VS	VS	52
VC 1163-D	BPI-Mg 2	1.54	2.41	1.98	67	MR	MS	53
VC 1973-A	Shanhua	1.74	2.19	1.97	80	MS	MS	61
VC 1089-A[y]	ASVEG '78/Manyar	1.40	2.40	1.90	80	MR	MS	51
VC 1131-B	Type 77	1.52	2.27	1.90	80	HR	MR	51
VC 1628-A	Tainan #3	1.54	2.18	1.86	77	VS	VS	59
VC 1000-D[y]	Station 46	1.50	2.03	1.77	64	MR	MS	53
V 2773	Nuri	1.77	1.64	1.70	64	MR	MR	33
V 1388	King	1.41	1.64	1.53	74	VS	MS	67
VC 1560-D (Ck)		1.44	1.78	1.61	62	HR	HR	58
Mean		1.56	2.09	1.83	73			54
CV (%)		12.2	9.7	10.8	5.6			6.0
LSD (.05)		0.28	0.29	0.20	4.1			3.3

[z]CLS = Cercospora leaf spot; PM = powdery mildew; MR = moderately resistant; MS = moderately susceptible; HR = highly resistant; VS = very susceptible. [y] Dull seed coat.

Conclusion

Selections with high yield potential combined with resistance to CLS and PM and having bigger seeds, less sensitivity to photoperiod, and different seed coat luster have been identified; however, improvement is needed for synchronized maturity and disease resistance. The highly significant positive correlations between number of pods per plant and yield indicated that traits influencing more pods/plant must be emphasized in breeding programs to improve seed yield.

Evaluating Mungbean Breeding Lines for Disease Resistance

Introduction

Cercospora leaf spot (CLS) and powdery mildew (PM) are the two major diseases common to most of the mungbean-growing areas. To develop disease-resistant lines and identify sources of resistance, all the breeding lines were evaluated under various yield trials, and selected accessions were routinely evaluated in different seasons.

Materials and Methods

Two hundred and fifty breeding lines and 19 accessions in spring, 330 breeding lines and 7 accessions in summer, and 319 breeding lines and 6 accessions in fall were evaluated in a disease

nursery. The plantings were made on 7 March, 17 July, and 13 September, respectively. Each entry was planted in a single-row plot, 2 to 2.5 m long and 0.5 m apart, with two replications. Susceptible cultivar, V 1944 in spring and fall and V 2010 in summer was planted in a band 1 m in width across the rows between two columns of test lines. Resistant checks, VC 1560-D in spring and V 2773 in summer and fall were planted in every sixth row.

CLS was rated in summer and fall and PM in spring and fall under natural epiphytotic conditions. The lines showing resistance better than that of the resistant check were considered highly resistant (HR). Those which performed similarly to the resistant check were identified as moderately resistant (MR). Lines which were intermediate between the resistant and susceptible checks were regarded as moderately susceptible (MS), and those with performance similar to the susceptible check were classified as very susceptible (VS).

Results and Discussion

Out of 238 breeding lines and six accessions evaluated through three seasons, seven breeding lines were consistently rated as highly resistant and 80, as moderate to highly resistant to both CLS and PM (Table 10). The seven breeding lines highly resistant to both diseases are listed in Table 11.

Table 10. Disease ratings of 238 breeding lines and six accessions tested over three seasons in 1985, AVRDC.

PM Rating	CLS Rating HR	MR	MS	VS	Total[z]
HR	7	9	6	0	22(0)
MR	13	58	32(1)	5	108(1)
MS	6	38(1)	40	12	96(1)
VS	0	2	6(1)	4(3)	12(4)
Total	26(0)	107(1)	84(2)	21(3)	238(6)

[z]No. in parenthesis means accession

Table 11. Performance of the seven breeding lines highly resistant to both CLS and PM in different yield trials.

Selection No.	Parentage	Yield (t/ha) sp	su	mean	% 1st H.[z] sp	su	Yield Trial
VC 3528-2B-3-B-2-B[y]	VC 1560D/VC 2533A	0.91	2.02	1.46	68	42	AYT
VC 3543-B-2-1-1-B[y]	VC 2772A/VC 2530C	0.87	2.65	1.76	85	52	IYT
VC 3732-3-3-B-1-B	Shanhua 1/VC 2530C	0.87	2.31	1.59	73	44	IYT
VC 3748-3-B-1-2-B[y]	VC 1562A/VC 2572A	0.78	2.06	1.42	91	50	IYT
VC 3749-1-B-2-1-B[y]	VC 1562A/VC 2719A	0.67	1.90	1.29	85	48	IYT
VC 3854-2B-1-1-B	VC 3749/VC 1628A	1.44	1.78	1.61	45	78	PYT-I
VC 3868-2B-3-1-B	VC 1560D/Pag-asa 2	1.20	1.72	1.46	49	68	PYT-I

[z]% 1st harvest. [y]Insensitive to photoperiod.

Conclusion

Improved levels of resistance to CLS and/or PM have been incorporated in more new breeding lines. A breeding program to incorporate both disease resistance and photoperiod-insensitivity will be emphasized in the future.

International Cooperation

During 1985 we have distributed seed packets of 824 breeding lines and 428 accessions to 67 cooperators in 23 countries.

Ecuador. Ing. Hector Buestan R. reported that AVRDC mungbean breeding line VC 1163 was released in Ecuador in 1985 and named as cv. Boliche 451.

Indonesia. Two AVRDC mungbean lines were released as cvs. Gelatik and Walet in 1985. Two sets of 14 AVRDC mungbean lines and one local check cultivar were evaluated at Pasar Jumat and Citayam in May and October 1984, respectively. Ten lines in Pasar Jumat significantly outyielded the check cultivar Bhakti. In Citayam, only VC 2768 A significantly outyielded Bhakti (Table 12). Mrs. Riyanti Sumanggone also indicated that 12 of the 14 AVRDC breeding lines were resistant to leafspot disease.

Table 12. Yield and 1000-seed weight of AVRDC mungbean lines grown in Pasar Jamat and Citayam, Indonesia.

AVRDC No.	Pasar Jamat		Citayam	
	yield (t/ha)	1000-seed wt (g)	yield (t/ha)	1000-seed wt (g)
VC 1560-D	2.05	54	2.03	55
VC 2307-A	1.89	40	1.52	40
VC 1628-A	1.78	53	1.91	54
VC 1000-C	1.74	52	1.65	53
VC 1482-E	1.63	48	1.56	47
VC 2768-A	1.61	58	2.69	57
Bhakti (Ck)	0.85	58	2.01	58
Mean of 15 entries	1.47	52	1.90	52
CV (%)	18.4		14.7	
LSD (.05)	0.39		0.40	

Iran. Dr. Behrooz-Sadri, Ministry of Agriculture and Rural Development, S.P.I.I., Karadj, conducted a yield trial with 12 AVRDC mungbean lines and two local check cultivars in summer 1985. Local check cultivar Gohar produced the highest yield of 1.69 t/ha. VC 1973 A was the only comparable line which produced 1.53 t/ha. Another check cultivar, Partoe, was the third highest-yielder with 1.40 t/ha. Cvs. Gohar and Partoe were included in our germplasm collection on June 1985 and will be used as parental lines in our breeding program.

Peru. Dr. Marco A. Neciosup G., plant breeder, INIPA-CIPA II, Chiclayo, reported that VC 1974 A yielded 2.21 t/ha, 87% of which was obtained from the first harvest. VC 1089 A produced 1.99 t/ha, 69% of which came from the first harvest in the 1984 trials. It is considered for release because of its early maturity, big seed size, and resistance to powdery mildew and viruses.

Philippines. Five AVRDC mungbean lines were evaluated and three showed yields similar to that of the check cultivar (Table 13). In another set of eight AVRDC lines tested against three local check cultivars by Mr. Mariano Canute at Benguet, La Trinidad, four had yields comparable to that of the check cultivar (Table 14).

Thailand. A series of yield trials with AVRDC mungbean breeding lines were conducted by the TOP/AVRDC Legume Program. The Thai national cultivar U-thong 1 (AVRDC accession V 3404) was used as check in all the trials. Statistical analysis showed that none of the breeding lines

Table 13. Performance of AVRDC mungbean lines at IRRI, Laguna, Philippines, 1985.[z]

AVRDC No.	Yield (t/ha)	Days to 1st Flowering	Plt Ht (cm)	Pods/ Plt	1000-Seed Wt (g)	CLS	PM
VC 2768-A	1.60	29	57	10.0	65.3	2.3	3.5
VC 1560-D	1.55	31	57	15.3	69.9	1.5	1.5
VC 1973-A	1.54	30	61	12.0	72.1	4.2	3.8
Pag-asa 1 (Ck)	1.45	28	61	12.3	62.3	3.2	3.5
Mean of 6 entries	1.49	29	57	12.8	67.5	2.7	3.1
CV (%)	8.6						
LSD (.05)	0.23						

[z]Sown: 23 Jan. 1985; harvested: 19 and 27 March 1985; plot size: 12 m² (4 rows x 6 m x 0.5 m); harvested area: 6 m²; no. of reps: 3; latitude: 14°13'N; longitude: 21°E; elevation: 23 m; season: spring; rainfall during crop season: 28.7 mm; cooperator: Antonio C. Morales, Rice Farming Systems Program, IRRI.

Table 14. Performance of selected AVRDC mungbean lines at Benguet, La Trinidad, Philippines.

AVRDC No.	Yield (t/ha)	Pods/ Plant	Seeds/ Pod	1000-Seed Wt (g)	PM
VC 1482-D	1.65	24.0	8.3	61	3
VC 2755-A	1.31	24.7	6.3	59	4
VC 2764-B	1.27	17.0	6.0	59	4
VC 1560-D	1.23	15.3	7.3	54	4
MG 50-10-A (Ck)	1.22	31.0	9.0	61	4
Mean of 11 entries	1.22	21.3	6.5	56	4
CV (%)	26.9				
LSD (.05)	0.57				

significantly outyielded the check in the elite and advanced yield trials (Table 15). However, in the intermediate yield trials, five lines performed better with more than 3 t/ha (Table 16).

U.S.A. Mr. L. J. Johnson of Sacramento Valley Milling Co., reported that 30 promising AVRDC lines were evaluated in two row plots, 5 m long with three replications. None of the AVRDC lines yielded more than the check cultivar H2M 188, a commercial variety selected from Berken, which yielded 1.99 t/ha. However, VC 2901 (1.67 t/ha) may have potential because it flowered one week earlier than H2M-188.

International Mungbean Nursery (IMN)

The 12th IMN consisted of six selected national cultivars and 14 AVRDC breeding lines. A total of 67 sets were distributed to 31 countries. Data were received from 24 cooperators in 14 countries, one of which did not give any yield data. The mean yield of the 20 entries over 21 locations was 1.09 t/ha; and VC 2768-A, also the highest yielder in the 11th IMN trials, produced the highest average yield of 1.19 t/ha.

Seven AVRDC breeding lines (VC 2768-A, VC 1973-A, VC 2719A, VC 2764-A, VC 1628-A, VC 2523-A, and VC 2768-B) outperformed the highest yielding national cultivar V 3476 which produced an average of 1.11 t/ha. In Potchefstroom, South Africa, the local check line, VC 1647B, also an AVRDC breeding line, produced the highest yield. The mean yields of the top three high-yielding entries and their mean disease ratings at each location are shown in Table 17.

Table 15. High-yielding AVRDC mungbean lines from the elite and advanced yield trials of the TOP/AVRDC Legume Program, Thailand 1984.

AVRDC No.	Yield (t/ha)	% 1st Harvest	Plt Ht (cm)	DF[z]	Pods/ Plant	1000-Seed Wt (g)
A. Elite trial						
VC 2764 C	3.21	68	68	33	26.9	54
VC 2720 A[y]	3.19	70	89	35	26.5	54
VC 2747-B-9-3B	3.14	67	80	31	20.5	61
VC 2520 A[y]	3.11	65	67	35	35.2	50
VC 2762-B-45-3B	3.09	65	73	34	30.9	59
VC 1210 A-4-3B	3.02	64	63	33	24.4	64
V 3404 (Ck)[y]	2.49	71	85	35	24.7	71
Mean of 18 entries	2.88	71	67	33	30.0	62
CV (%)	16.3					
LSD (.05)	0.90					
B. Advanced trial						
VC 1482 C 15 1-2B	3.70	71	66	32	22.7	58
VC 2719-29-B-5-3B	3.67	67	81	34	22.2	62
VC 2763-13-B-2-2B	3.42	73	76	31	25.3	62
VC 2763-39 B-10-2B	3.31	70	89	34	19.7	66
VC 2772 18 B-1 2B	3.15	64	85	35	19.5	64
VC 2772-18 2B 11-2B	3.14	67	72	35	17.8	67
VC 1482 C-1-3B	3.12	74	67	31	23.4	57
VC 1973 A (Ck)	3.06	71	79	33	21.7	75
VC 2762 B 45 1 2B	3.00	59	72	33	26.8	70
V 3404 (Ck)	2.84	70	98	35	20.6	74
Mean of 16 entries	3.11	68	76	33	22.8	66
CV (%)	12.8					
LSD (.05)	0.87					

[z]Days to 1st flowering [y]Shiny seed coat.

Table 16. List of AVRDC breeding lines yielding over 3 t/ha from the intermediate yield trials of TOP/AVRDC Legume Program, Thailand 1984.

AVRDC No.	Yield (t/ha)	% 1st Harvest	Plt Ht (cm)	Days to 1st Flowering	Pods/ Plant	1000-Seed Wt (g)
VC 2742 16 B 1 2B	3.28	68	67	32	29.7	78
VC 2778 18 B 1 2B	3.24	69	78	35	20.5	56
VC 2750 4 B 4 2B	3.13	72	68	32	25.8	64
VC 2762 B 67 B 1 2B	3.09	72	75	33	33.3	54
VC 2719-29-1-B 8 2B	3.07	63	91	36	22.5	50
VC 2762 8-2B 9 2B	3.01	65	77	35	19.8	61
V 3404 (Ck)	2.66	63	96	34	13.0	72
Mean of 20 entries	2.86	67	75	34	27.6	64
CV (%)	8.1					
LSD (.05)	0.39					

Table 17. Highlights of the 12th IMN results received from 16 locations in 14 countries.

Location	Country	Mean Yield (t/ha)	Top Three Highest-Yielding Entries 1st	2nd	3rd	Yield (t/ha) (Ck cultivar)	Mean of Disease Rating[z] CLS	PM	others
Yezin	Burma	1.35	VC 2768A (1.69)	VC 1628A (1.66)	VC 1973A (1.61)	1.07 (Yezin – I)	–	–	–
Chatham	Canada	–	VC 2307A	VC 1482E	VC 1562A	–	–	–	Bact. Blight 2.9
AVRDC	Taiwan (Sp)	1.43	V 3726 (1.83)	V 2984 (1.80)	VC 2768A (1.78)	–	–	–	–
AVRDC	Taiwan (Su)	1.73	VC 2764A (2.09)	VC 2750A (2.08)	VC 1628A (2.08)	–	2.7	–	–
AVRDC	Taiwan (Fa)	1.35	VC 2778A (1.64)	VC 2719A (1.57)	VC 1973A (1.50)	–	3.0	3.3	–
Kupang	Indonesia (Feb)	0.76	VC 2719A (1.23)	VC 1482E (1.18)	V 2010 (1.10)	0.68 (No. 129) 0.34 (King)	1.2	–	–
Kupang	Indonesia (Dec)	0.63	VC 2719A (1.28)	VC 2523A (1.26)	VC 1000C (1.20)	0.41 (No. 129) 0.14 (King)	1.0	–	–
Suweon	Korea	0.62	VC 1000C (1.24)	V 2984 (0.94)	VC 1973A (0.92)	–	3.0	–	MYMV 2.4
Sarawak	Malaysia	1.57	VC 2768A (2.11)	VC 2778A (1.92)	VC 1628A (1.84)	–	–	–	–
Khumaltar	Nepal	0.25	VC 2523A (0.42)	VC 2750A (0.41)	VC 2719A (0.39)	0.39	1.0	1.2	MYMV 0.4
Faisalabad	Pakistan	1.86	VC 1628A (2.49)	VC 2764A (2.39)	VC 2768B (2.35)	1.38 (V Nab Mung 28)	–	–	–
Lahore	Pakistan (Mar)	0.25	VC 1562A (0.45)	VC 1973A (0.45)	V 3476 (0.44)	0.23 0.21	–	–	–
Lahore	Pakistan (July)	–	V 2272 (0.57)	V 6017 (0.51)	VC 2719A (0.44)	–	–	–	MYMV 5.1
Los Baños	Philippines	1.08	VC 2768A (1.35)	VC 1973A (1.27)	VC 2750A (1.26)	–	4.6	–	Virus 1.3
Laguna	Philippines	0.49	VC 1973A (0.67)	VC 2764A (0.64)	VC 2768B (0.60)	–	2.3	–	–
Nan	Thailand	1.14	VC 2768A (1.58)	VC 1973A (1.50)	VC 1628A (1.41)	0.85	3.0	–	Virus 1.7
Gonawila	Sri Lanka	0.42	VC 2750A (0.65)	VC 2755A (0.65)	VC 1628A (0.60)	0.48 0.46	–	–	–
Kilosa	Tanzania	1.65	VC 1973A (2.07)	VC 2764A (1.82)	VC 2768A (1.80)	1.90 (IMARA) 1.86 (NURU)	2.1	1.6	–
Potchefstroom	South Africa (1)	1.36	VC 1973A (1.63)	V 3726 (1.60)	V 2984 (1.57)	1.73 (VC 1647B)	–	–	Virus 1.6
Potchefstroom	South Africa (2)	1.58	V 3476 (2.22)	VC 2768A (1.93)	VC 2307A (1.92)	1.30 (VC 1647B) 1.80 (Berken)	–	–	–
Texas	U.S.A.	1.27	VC 2768B (1.80)	VC 2755A (1.65)	VC 2768A (1.60)	1.46 (Lincoln)	–	–	Virus 1.44
Mean	1.09 ± 0.12								

[z]0 = highly resistant and 5 = highly susceptible.

Mungbean Entomology

Screening Segregating Populations for High Yield and Resistance to Beanfly

Introduction

In autumn 1979 three mungbean accessions were found which had a moderate level of resistance to beanflies, mainly Ophiomyia phaseoli (Diptera: Agromyzidae). In 1980, 1981, and 1982 AVRDC mungbean breeders made a series of crosses involving one beanfly-resistant accession and high-yielding, disease-resistant breeding lines. In 1985 F4 to F8 populations involving all crosses were planted. We bulked and advanced generation in one cross, made selection for high yield in another, and selected for beanfly resistance in the third.

Materials and Methods

The land was rototilled, applied with basal fertilizers, and worked into 0.75-m-wide beds. The seeds were sown on top of the bed. Each plot consisted of a single row of various lengths, depending upon the nature of the experiment and the amount of seeds available. The segregating materials screened during 1985 are shown in Table 1.

Table 1. Segregating populations screened in 1985.

Crosses	Generation	No. of Entries	Remarks
1980	F8	95	Selected for beanfly resistance
1981	F7	52	Selected for high yield
1982	F6	59	Generation advance
1983	F5	59	Generation advance

1. The selection for beanfly resistance was conducted in a three-replicated trial, with each entry planted in a 5-m-long single row. Four weeks after germination, we uprooted 30 plants, cut their stems, and recorded the number of beanfly larvae and pupae found inside, as well as the number of plants with visible beanfly damage.

2. In the selection for high yield, each entry was planted in a 20-m-long row. At pod setting and harvest, in cooperation with the mungbean breeding staff, we examined each plant carefully and selected those that had a large number of pods/plant, bigger seeds, and early and uniform maturity.

3. In two trials to advance the generation, each entry was planted in a 5-m-long row. The crop was raised until harvest according to customary cultural practices, except that no insecticide was applied. This ensured the selection for beanfly resistance or high yield under natural beanfly infestation in the field. At harvest the seeds were bulked for use in the future.

Results and Discussion

Selection for beanfly resistance. The entries included in this trial were selected for high yield based on single-plant characteristics in autumn 1984. Of the 95 entries tested five had comparable beanfly damage as the resistant parent, V 4281. All the entries were significantly less damaged than the susceptible parent (Table 2). The number of insects found within the stems, as well as beanfly-damaged plants (with insects present or total insect number) in the five resistant entries were significantly less than those in the standard susceptible parent V 2184.

Table 2. Performance of selected breeding lines for resistance to beanflies.[z]

Entry No.	No. Larvae + Pupae/30 Plants	Damaged Plants, with insects	without insects	total
F8-VC2839-56	3.7b	12.2b	47.8	60.0b
F8-VC2839-70	4.0b	12.2b	50.0	62.2b
F8-VC2839-71	3.3b	11.1b	47.8	58.9b
F8-VC2839-75	2.3b	7.8b	38.9	46.5c
F8-VC2839-89	4.0b	12.2b	46.7	58.9b
V 4281[y]	6.0b	18.8b	40.0	58.8bc
V 2184[x]	15.3a	41.1a	43.3	84.4a

[z]Planting date 10 Sept 1985; observation date 12 Oct 1985.
[y]Resistant parent [x]Susceptible parent

The fact that these entries and their resistant parents had fewer damaged plants with beanfly larvae or pupae present, indicates the possibility of an antibiotic factor which causes death to the larvae in the early instars. These resistant lines are being multiplied for yield trials in the 1986 spring, summer, and autumn seasons. After their yield performance is evaluated, superior lines will be distributed to cooperators.

Selection for high yield. The entries included in this test were bulked up to F7. Based on flowering date and pod setting, entries were first selected for earliness. At harvest when most of the pods were ripe, these entries were further selected for high yield based on yield components of individual plants. Over 100 plants were selected. The seeds harvested from these plants will be multiplied in spring 1986 and planted in autumn 1986 for screening for beanfly resistance.

Generation advance. Two sets of materials in this test were harvested and seeds of individual entries bulked. These entries will be planted in autumn 1986 to select high yielding plants before evaluating them for beanfly resistance.

Conclusion

Three mungbean accessions were found moderately resistant to beanflies, and breeding for resistance to these pests has been done. In 1985 we selected five breeding lines with moderate resistance and, based on single plant characters, have a yield potential higher than the resistant parents. These entries will be planted in a series of yield trials before releasing them to national programs.

Characterization of Beanfly Resistance in Resistant Mungbean Accessions

Introduction

In the 1979-80 season three mungbean accessions were found with moderate levels of resistance to beanflies. With the help of plant breeders, a resistance-breeding program was immediately initiated;

and a year later, a small-scale research on the characterization of resistance mechanism was started. Our laboratory feeding trials with two polyphagous insects in 1984 indicated the possibility of antibiosis as the resistance mechanism. Since, because of the insect's characteristic way of feeding, it is not possible to assess the ant biosis of these accessions to beanflies directly, in 1985 a detailed field study was conducted to get at least an indirect evidence of this antibiosis.

Materials and Methods

A parcel of land away from areas of frequent insecticide use was rototilled and worked into 75-cm-wide beds. These beds were further divided into 10-m-long plots. Seeds of three beanfly- resistant accessions (V 2396, V 3495, and V 4281) and one susceptible accession (V 2184) were sown as a single row on each bed. Each accession was sown in four randomly selected plots. The crop was raised for five weeks according to customary cultural practices, except that no insecticide was used.

Three and five weeks after germination, we uprooted 100 plants from each plot and cut open the stems and tap roots of each. The number of beanfly larvae and pupae found inside each plant, as well as the number of plants with visible beanfly damage, were recorded. The insect number and plant damage data were analyzed by Duncan's multiple range test.

Results and Discussion

Insect count and plant damage are summarized in Table 3. As in the past, the number of beanfly larvae and pupae found inside beanfly resistant accessions was significantly less than in the susceptible cultivars. Analysis indicated that, although no difference was found at three weeks after germination, the proportions of insects pupated were significantly less in two of the three resistant accessions than in the susceptible check. In resistant accessions the number of plants damaged was also significantly less. The percentage of damaged plants with insects still present inside each stem was likewise significantly less in resistant accessions than in the susceptible ones.

Table 3. Characteristics of beanfly infestation in beanfly-resistant and susceptible mungbean accessions.[z]

Accession[y]	No. Larvae + Pupae per 100 Plants		Pupae (%)		Plant Damage (%) with insects		Plant Damage (%) without insects		Plant Damage (%) total	
	3 WAE[x]	5 WAE	3 WAE	5 WAE	3 WAE	5 WAE	3 WAE	5 WAE	3 WAE	5 WAE
V 2184 (S)	32.5 a	24.4 a	64.3 a	59.6 a	29.1 a	22.9 a	39.5 a	42.8 a	68.6 a	65.7 a
V 2396 (R)	8.0 b	7.8 b	55.6 a	47.8 ab	8.1 b	7.7 b	29.6 b	29.9 b	37.7 b	37.6 b
V 3495 (R)	6.2 b	7.3 b	67.6 a	32.1 bc	6.2 b	7.5 b	27.9 b	28.0 bc	34.1 b	35.5 bc
V 4281 (R)	5.4 b	7.0 b	61.4 a	25.5 c	5.7 b	6.6 b	27.2 b	23.8 c	32.9 b	30.4 c

[z]Data are the combined analysis of four plantings, one each in July, Aug., Sept., and Oct. 1985. At each planting entries were replicated four times. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test. [y]S = beanfly susceptible; R = beanfly-resistant. [x]WAE = weeks after emergence.

Conversely, the damaged plants with no remains of insects were significantly more in beanfly-resistant than in susceptible accessions. This indicates that, in resistant accessions after initial feeding, the larvae died. It was not possible to distinguish the dead early-instar larvae from the damaged plant tissue. The premature death of the larvae along with the reduced rate of larvae becoming pupae in resistant accessions, indicate that certain biochemical factors inside the stems of resistant accessions are antibiotic to the beanfly larvae.

Conclusion

In 1980 three mungbean accessions were found resistant to beanflies. A detailed investigation of insect development and the nature of plant damage in resistant and susceptible accessions indicated that certain biochemical elements in resistant plants adversely affect the development of beanflies infesting these plants.

Screening of Mungbean Germplasm for Resistance to Asiatic Corn Borer

Introduction

In recent years, Asiatic corn borer, *Ostrinia furnacalis* (Lepidoptera: Pyralidae), has become an important pest of mungbean in Taiwan and elsewhere in Asia. In Taiwan this pest attacks mungbean in summer and is practically absent from early autumn to late spring. The insect larvae bore into stems, branches, and pods. As a consequence of its damage, the plant is weakened which results in wilting of the shoots. Larval feeding inside the pods causes direct yield loss. In 1985, therefore, we screened part of our mungbean germplasm for resistance to this pest.

Materials and Methods

A 1-ha parcel of land away from the areas of frequent insecticide use was rototilled, applied with basal fertilizers, and worked into 75-cm-wide beds. These beds were further divided into 4-m-long plots. The germplasm included in this screening comprised 2,000 accessions and 159 breeding lines from the AVRDC mungbean breeding program. Seeds of the 2,159 entries were planted in a single row on 4-m-long plots. After every 10 rows of mungbean, one row of corn was planted two weeks ahead of mungbean.

Six weeks after the germination of corn, each corn plant was inoculated with laboratory-reared Asiatic corn borer pupae. The insect-infested corn plants acted as a source for Asiatic corn borer infestation of mungbean planted between corn rows. By the time most mungbean entries flowered, the corn plants were riddled with borers which assured a uniform infestation of mungbean.

Seven to eight weeks after germination we made the first observation for plant damage. In each entry we recorded the number of insect-damaged plants and total number of plants. Insect damage can be easily judged by the wilting and hollowing of the affected branch and the collection of frass around an entry hole in the stem. The percentage of damaged plants was recorded for each entry in the experiment.

At harvest, we gathered all the pods and recorded the number of damaged and total pods for each accession. Cornborer damage to the pods can be judged by the presence of feeding holes in the pods. No other pod borer or pod-feeding insect was present during the season. The percentage of pods damaged was calculated for each accession.

The percentages of plant and pod damage were analyzed by a statistical procedure based on the mean of all entries and the standard deviation (sd). The accessions that had insect damage less than mean - 2sd were considered highly resistant (HR); between mean - 1sd and mean - 2sd, moderately resistant (MR); between mean and mean - 1sd, having low resistance (LR); between mean and mean + 2sd, susceptible (S); and more than mean + 2sd, highly susceptible (HS).

Results and Discussion

The results of the distribution of mungbean accessions in various resistance categories, based on both plant and pod damage criteria, are summarized in Fig. 1.

Asiatic corn borer damage varied from 0 to 100% of the stems and branches and from 0 to 94% of the pods. On the basis of stem and branch damage, there were 185 MR, 1139 LR, 744 S, and 91 HS entries. On pod damage, only 1,733 of the 2,159 entries planted, could be evaluated as the others were severely ravaged by the Asiatic corn borer and did not have pods. There were 21 HR, 210 MR, 738 LR, 513 S, and 25 HS entries in this group.

The following 19 entries were moderately resistant based on stem and branch damage, and were moderately and highly resistant based on pod damage (Table 4), namely: V 1037, V 1038, V 1216, V 1753, V 2324, V 2475, V 2484, V 2489, V 2514, V 2550, V 2559, V 2716, V 2719, V 2739, V 2988, V 3034, VC 2750-A, VC 2778-A, and VC 2719-A. These entries will be studied in summer

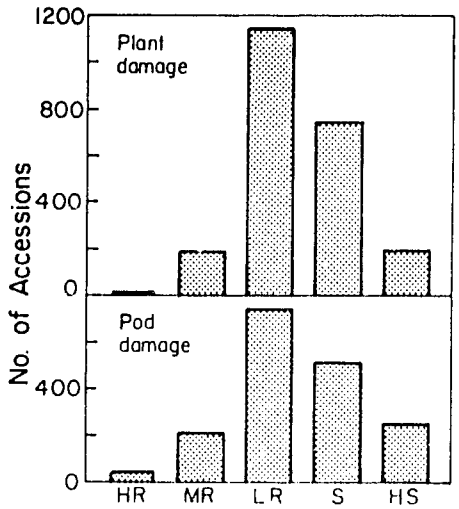

Fig. 1. Distribution of mungbean germplasm among the various categories of resistance to Asiatic corn borer based on stem, branch, and pod damage.

1986 before their inclusion in the breeding program.

The performance of 19 entries that fell in MR categories based on stem and branch damage basis and in MR or HR categories on pod damage basis is summarized in Table 4. These entries and selected others that had least insect damage by either of the two criteria will be studied in summer 1986 before initiating the resistance breeding program.

Table 4. Performance of selected mungbean entries in the screening for resistance to Asiatic corn borer.

Entry	Stem/Branch Damage (%)	Resistance Rating	Pod Damage (%)	Resistance Rating
V 1037	0.0	MR	7.69	MR
V 1038	0.0	MR	0.00	HR
V 1216	2.50	MR	0.00	HR
V 1753	1.11	MR	9.62	MR
V 2324	0.0	MR	12.33	MR
V 2475	0.0	MR	8.11	MR
V 2484	0.0	MR	5.77	MR
V 2489	2.94	MR	12.50	MR
V 2514	2.63	MR	8.70	MR
V 2550	0.0	MR	9.09	MR
V 2559	0.0	MR	7.35	MR
V 2716	0.0	MR	11.30	MR
V 2719	0.0	MR	8.82	MR
V 2739	0.0	MR	12.73	MR
V 2988	2.70	MR	7.41	MR
V 3034	2.22	MR	6.19	MR
VC 2719A	0.0	MR	10.98	MR
VC 2750A	2.86	MR	12.73	MR
VC 2778A	0.0	MR	11.61	MR
Damage Range	0 to 100		0 to 94	
Damage Mean	16.75		24.25	

Conclusion

We screened 2,159 mungbean accessions for resistance to Asiatic corn borer. Based on insect injury to stems and pods, 19 entries were least damaged. These entries will be evaluated further in 1986 before they are judged suitable for inclusion in the resistance breeding program.

Asiatic Corn Borer Damage in Mungbean

Introduction

Asiatic corn borer which infests mungbean in all parts of Southeast Asia is recently becoming more and more important in Taiwan. This could be due to the increased cultivation of corn, its primary host. The insect larvae bore into the stems, branches, and green pods and feed on developing seeds. Since practically no information exists on its biology and nature of damage in mungbean, in summer 1985 various aspects of this damage was studied both in the field and in potted plants in the greenhouse.

Materials and Methods

Certain biological parameters, such as oviposition, which have a direct bearing on the extent of infestation and the nature of insect damage in mungbean plants were studied in the laboratory, greenhouse, and field. The eggs and larvae of the corn borer were collected from the AVRDC mungbean fields. Initially, the insects were reared on an artificial diet and on corn cobs, in the laboratory.

For the oviposition study, we raised mungbean plants in clay pots in the greenhouse. Plants ranging in age from two to seven weeks were selected. Two potted plants of each age group were placed in a 2 m x 1 m screen cage, and a large number of freshly emerged Asiatic corn borer adults were released inside the cage. After a four-day exposure the number of eggs on the main stem, branches, leaves, and pods were recorded. In a related study we placed seven-week-old plants inside 0.5 x 0.5 m net cages and studied the location of oviposition in the upper, middle, and bottom third of the plant.

In a field study, we uprooted 100 green pod-bearing mungbean plants grown as guard rows of an experiment where no insecticides were used and where the population of the insect was augmented by corn plants infested with laboratory reared insects. Each plant was dissected open and observed for the location of larval feeding and the developmental stage of the insect present inside the plants.

Results and Discussion

The results of the oviposition study in the greenhouse are presented in Tables 5, 6, and 7. Oviposition was predominant on leaves, but some eggs were also laid on the pods. The insect laid substantially more eggs on the lower than on the upper leaf surface (Table 5). No eggs were found on the branches.

Table 5. Oviposition characteristic of Asiatic corn borer in mungbean plants.[z]

Plant Part	No. Eggs/Plant
Leaves: upper surface	25.3
lower surface	100.8
Pods	2.0
Stem and branches	0

[z]Data are means of four replicates, each replicate had two plants.

The insect preferred to lay eggs on the foliage located in the upper one third of the plant, the middle, and the bottom, in that order (Table 6). This preference could be related to the presence of mungbean pods, which the insect infested, in the upper part of the plant.

The insect laid more eggs on older than on younger plants (Table 7). This could be due to the greater amount of foliage and green pods, and larger and bigger branches on which to feed in older plants.

Soon after mating, the males died. The females laid masses of milky white eggs which gradually turned black as the incubation period progressed. Eggs adhered tightly to whatever plant surface they were laid on. Incubation period was three to five days.

Table 6. Oviposition preference of Asiatic corn borer for various regions of the mungbean plant.[z]

Plant Region	No. of Eggs/Plant
Upper third	89.3
Middle third	30.7
Bottom third	8.1

[z]Data are means of four replicates; each replicate had two plants.

Table 7. Preferred mungbean age for oviposition by the Asiatic corn borer.[z]

Plant Age (weeks)	No. Eggs/Plant
2	3.0
4	6.8
5	20.9
6	40.4
7	89.7

[z]Data are means of four replicates; each replicate consists of two plants.

A detailed survey of 100 mungbean plants revealed that the Asiatic corn borer damaged mungbean shoots (stems + branches) in 76% of the cases and roots in 24%. The damage to the shoot started from 33 cm above the soil surface in mature plants. Among damaged shoots, 59.5% was in pods, 29.4% in the node, and 11.1% in the internodes (Table 8). It must be emphasized here that, in the case of damaged nodes, the larvae also fed in the internodes, but the exit holes were at the nodes. This insect, thus, appears to be more a pest of pods than of other plant parts. As a result of larval feeding the plant becomes weak, shoots wilt, and at times the plant dies. In damaged plants the pods mature earlier than in healthy plants, but the seeds are distinctly smaller and the yield lower.

The larvae of all instars and even pupae were found within the damaged plant parts (Table 8). In the majority of the cases the larvae were in their 2nd or 3rd instar. The pupae were encountered in 15% of the cases.

Table 8. Developmental stages of Asiatic corn borer found within the dissected mungbean plant parts.[z]

Insect Stage		Distribution (%)
Larvae:	1st instar	9.5
	2nd instar	33.3
	3rd instar	26.2
	4th instar	10.3
	5th instar	5.6
Pupae		15.1

[z]Data are from a survey of 100 damaged plants.

Conclusion

Asiatic corn borer is becoming a more serious pest of mungbean. The insect lays eggs on the underside of the leaves on the upper plant part of older plants, and the larvae bore inside stems and pods. Plants damaged in the stems are weakened and at times die of infestation.

Mungbean Pathology

Effect of Virus Isolate M-25 on Mungbean Yield

Introduction

The criteria used to determine the importance of plant pathogens are a wide host range, ease of transmission by insects or seed, high incidence, wide geographic distribution, and yield reduction. The first two have already been studied for mungbean virus isolate M-25, and it was found that the virus has a wide host range among leguminous crops and is transmitted by seed and by aphids in a nonpersistent manner. This study was conducted to determine whether infection of mungbean by the M-25 isolate would result in yield reduction.

Materials and Methods

The experiment was planted on 18 April. Three mungbean lines (VC 1628-A, VC 2768-B, and VC 1000-C) found to be susceptible to isolate M-25 in a previous screening were tested. Plot size for each line was 5 x 1 m and consisted of one double row. One hundred seeds were planted per row (two seeds per hill). Spacing was 10 cm between hills and 50 cm between plants.

Treatments consisted of seven successive inoculations carried out at weekly intervals, beginning on 26 April and ending on 7 June. Inoculations were done at the following plant development stages: cotyledon, 1st trifoliate, 3rd trifoliate, 5th to 6th trifoliate, 7th trifoliate, 8th to 9th trifoliate, and 10th to 11th trifoliate. One double-row of each line remained uninoculated for control. Treatments were completely randomized within each block and the blocks were replicated three times (randomized complete block design).

The inoculum was obtained by homogenizing one part symptomatic leaves of *Phaseolus vulgaris* 'Bountiful' plants in five parts of 0.01 M phosphate buffer (pH 7.0) 14 days after inoculation.

Data collected included yield, 100-seed weight, percentage of seed germination (of 200 seeds per treatment) and transmission percentage of M-25 in the germinated seed.

Results and Discussion

Results are shown in Table 1. The three mungbean cultivars tested showed virus symptoms (mosaic) only after the first inoculation at eight days after sowing.

Similarly, only the first or the first two inoculations affected yield. Virus infection at 8 and 14 days after sowing reduced yield by 26% in VC 1628-A and by 29% in VC 1000-C. The yield of line VC 2768-B was reduced by 20% when infection occurred at eight days after sowing. Data show that virus infection had no effect on 100-seed weight and on the germination of seeds collected from inoculated plants of all three lines tested.

This study indicates the maximum yield reduction that can be expected when 100% of the plants are infected at different times after sowing. However, under natural conditions yield reduction is likely to be much less, because the primary inoculum in the field results from seed transmission which has been shown to be quite low, even when seeds originate from plants with 100% infection at the early growth stages.

Table 1. Average yields, 100-seed weights, germination percentages and seed transmissions of three advanced mungbean breeding lines inoculated with isolate M-25 at different dates.

Cultivar	Time of Inoculation	Yield/ Plt[z] (g)	100-Seed Wt[y] (g)	Germination (%)	Seed Transmission[x] (%)
VC 1628-A	4/26	7.4 b	5.5	93	1.6
	5/3	7.4 b	5.5	98	0
	5/10	9.7 a	5.3	97	0
	5/17	9.7 a	5.4	96	0
	5/24	10.1 a	5.3	97	0
	5/31	9.8 a	5.2	99	0
	6/7	10.5 a	5.2	96	0
	Control	9.7 a	5.3	98	0.5
VC 2768-B	4/26	8.6 b	6.0	96	0
	5/3	10.3 a	6.0	95	0
	5/10	10.4 a	5.9	94	0
	5/17	10.5 a	6.0	95	0
	5/24	10.7 a	5.8	94	0
	5/31	10.9 a	5.8	92	0
	6/7	10.2 a	5.9	94	0
	Control	10.5 a	5.9	94	0
VC 1000-C	4/26	5.7 c	5.6	93	0
	5/3	6.4 c	5.7	94	0
	5/10	8.0 b	5.8	98	0
	5/17	8.5 ab	5.7	94	1.1
	5/24	8.8 ab	5.4	94	0
	5/31	8.8 ab	5.4	93	0
	6/7	8.5 ab	5.5	96	0
	Control	9.4 a	5.6	96	0

[z]Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test. [y]Average of five different samples, 100 seeds each. [x]Percentage of germinated plants.

Conclusion

The host range of this virus, which has not been previously reported on this host in Taiwan, was mainly confined to the legume family. This study showed that a significant yield reduction occurred in mungbean when plants were infected at the early growth stages (up to 14 days after sowing). Germination and 100-seed weight were not affected, however. In terms of absolute yield loss, therefore, this virus is not considered very important. However, it is felt that, on the basis of its wide host range, seed transmissibility, and absence of resistance to this virus in the advanced breeding lines, it is justified to include it in the AVRDC breeding program.

Seed Transmission of a New Mungbean Virus and Screening for Resistance

Introduction

Two virus isolates (M-25, M-4) were previously recovered from mungbean which appeared to be serologically closely related to blackeye cowpea mosaic virus (BICMV) and adzukibean mosaic virus (AzMV). Because of their wide host range, seed transmission, and high incidence in AVRDC fields, it was decided to screen elite breeding lines for resistance to this virus, and also identify possible sources of resistance in the AVRDC germplasm collection.

Materials and Methods

Thirty-three breeding lines were screened with isolate M-25 and M-4. Twelve parents of breeding lines and 23 accessions reportedly resistant to mungbean mottle virus (MMV) were also tested. Thirty to 50 plants were inoculated and scored by the method described in the 1984 annual report.* Plants without symptoms or with very mild ones were checked by ELISA using pooled samples consisting of five leaves (one leaf each from five plants).

Seed transmission was tested in 13 mungbean lines (10 breeding lines and 3 accessions), 5 yard-long bean lines, and three cowpea lines. The plants were inoculated with isolate M-4 or M-25 at the primary leaf stage. Seeds were collected approximately three months after sowing. Two hundred seeds for each entry were sown in flats and observed for symptom expression up to the second trifoliate leaf stage. Infected seedlings were tested by ELISA. Of symptomless seedlings, 10 samples consisting of one leaf each from two randomly selected plants were tested for symptomless infection by the same method.

Results and Discussion

The rating method used did not attempt to assess the number of infected plants exactly, but rather to express infection as a range between the lowest and the highest possible percentages of infection. None of the breeding lines was found to carry high levels of resistance to the two virus isolates tested (Table 2). This was expected, since these lines were never selected for resistance to this virus in the breeding process. However, three lines (VC 1131-B, VC 2917-A, and VC 3004-A) had a lower possible percentage of M-25 infection than the other lines tested. These will be rescreened and rated by testing individual symptomless plants, rather than by testing pooled samples. With respect to virus isolate M-4, three lines showed infection rates of between 10 and 60%. These will be retested.

Table 2. Reactions of elite breeding lines to virus isolates M-25 and M-4.

Elite Breeding Line	% Infection[z]		Elite Breeding Line	% Infection[z]	
	M-25	M-4		M-25	M-4
VC 1000-C	19 to 93	15 to 74	VC 2768-A	NT	11 to 53
VC 1089-A	16 to 81	17 to 87	VC 2778-A	20 to 100	19 to 81
VC 1131-B	10 to 49	21 to 100	VC 2778-B	20 to 89	21 to 100
VC 1168-B	16 to 79	17 to 85	VC 2778-C	20 to 100	15 to 74
VC 1482-E	19 to 95	21 to 100	VC 2802-A	17 to 85	10 to 52
VC 1560-D	18 to 88	16 to 81	VC 2917-A	11 to 47	20 to 100
VC 1562-A	22 to 100	20 to 100	VC 2935-A	16 to 73	20 to 100
VC 1628-A	22 to 100	19 to 89	VC 2991-A	18 to 89	19 to 96
VC 1647-B	NT	16 to 80	VC 3004-A	8 to 40	17 to 83
VC 1973-A	21 to 100	11 to 78	VC 3011-A	20 to 98	17 to 87
VC 2307-A	26 to 100	15 to 76	VC 3012-B	18 to 89	21 to 100
VC 2523-A	21 to 100	18 to 87	VC 3029-A	19 to 95	21 to 100
VC 2572-A	9 to 43	20 to 100	VC 3178-A	27 to 100	20 to 100
VC 2719-A	9 to 45	12 to 60	VC 3301-A	20 to 100	20 to 100
VC 2720-A	16 to 78	16 to 81	VC 3580-A	14 to 70	11 to 57
VC 2750-A	NT	13 to 67	V 2010	NT	20 to 100
VC 2755-A	20 to 100	18 to 100	V 2272	NT	11 to 57
VC 2762-B	17 to 86	21 to 100	V 2984	NT	16 to 77
VC 2762-C	16 to 78	18 to 89	V 3476	NT	15 to 74
VC 2763-A	15 to 76	19 to 96	V 3726	NT	22 to 100
VC 2764-A	NT	18 to 100	V 6017	NT	16 to 78

[z]Expressed as disease incidence; NT = not tested.

*AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

With one exception, the 12 parents of the breeding lines were found to have a high percentage of infection with M-25 and M-4 (Table 3). Only V 3686, with a range of only 8 to 44% was more resistant than the others. This line will also be rescreened.

Table 3. Reaction to M-4 and M-25 of 13 parents of breeding lines and 23 accessions reported to be resistant to mungbean mottle virus.

Entry	% Infection[z]		Entry	% Infection[z]	
	M-25	M-4		M-25	M-4
Parents of elite breeding lines					
V 1066	20 to 98	18 to 87	V 1944	20 to 100	20 to 100
V 1104	21 to 100	22 to 100	V 1948	16 to 82	19 to 96
V 1377	20 to 98	18 to 87	V 1969	18 to 90	16 to 78
V 1387	19 to 95	19 to 97	V 3409	16 to 78	18 to 89
V 1394	17 to 83	19 to 95	V 3686	20 to 100	8 to 44
V 1411	16 to 74	15 to 73	V 5000	15 to 73	18 to 89
Accessions reported resistant to mungbean mottle virus					
V 1114	9 to 36	24 to 58 (3)	V 1696	31 to 100	35 to 87 (5)
V 1133	15 to 68	0 (1)	V 1745	0	0 (0)
V 1153	0	0 (0)	V 1811	30 to 100	20 to 60 (2)
V 1227	5	0 (0)	V 1831	14 to 71	0 (8)
V 1337	25 to 42	0 (0)	V 1878	11 to 44	45 to 100(0)
V 1353	3 fo 17	0 (0)	V 1972	15 to 59	2 to 11 (0)
V 1562	16 to 78	3 to 13 (3)	V 1976	18 to 44	5 to 18 (0)
V 1595	26 to 94	13 to 64 (2)	V 2082	51 to 100	30 to 98 (0)
V 1672	16 to 53	8 to 25 (3)	V 2194	2 to 11	4 to 22 (7)
V 1673	25 to 52	2 to 11 (5)	V 2260	4 to 21	0 (3)
V 1682	0	0 (0)	V 2310	13	0 (1)
V 1693	58 to 78	34 to 100 (6)			

[z]Disease incidence expressed as percentage of infected plants. Numbers in parenthesis indicate infection percentage with respect to the mungbean mottle virus

Resistance to M-25 and M-4 was, however, found in some lines reportedly resistant to mungbean mottle virus (Table 3). Three of these lines (V 1153, V 1682, V 1745) were found immune to both M-25 and M-4, and seven others (V 1133, V 1227, V 1337, V 1353, V 1831, V 2260, V 2310) to only M-4. Several lines were also identified with infection rates lower than 15% to either M-4 or M-25. All will be rescreened. These results also suggest that the unknown mungbean virus is probably not the same as the virus previously described as mungbean mottle virus, since several of the reported MMV-resistant lines do have high infection rates with either M-25 or M-4 or both.

Seed transmission was either absent or lower than 0.5% in the three cowpea cultivars tested (Table 4). Two yard-long bean lines (CP1 and CP44) had low seed transmission rates with isolate M-25. Isolates M-4 and M-25 were seed-tran mitted in, respectively, seven and six of the 13 mungbean lines tested. Seed transmission in these lines was generally low, ranging from 0.6 to 2.5%. Seed transmission in other lines was probably so low that it remained undetectable in the small sample size used.

Conclusion

A virus was isolated from mungbean which has not been reported on this crop in Taiwan. The virus characterized by host range, serological tests, and molecular weight of the protein coat appeared to be very closely related to both BICMV and AzMV. The elite breeding lines did not show good levels of resistance, but immunity to isolates M-25 and M-4 was found in several accessions. The virus was seed-transmitted at a low rate in mungbean and yard-long bean.

Table 4. Germination rates and seed transmissions of mungbean, yard-long bean, and cowpea lines infected with the unknown virus isolates M-4 and M-25.

Host	M-4		M-25	
	Germin. rate (%)	Seed trans. (%)	Germin. rate (%)	Seed trans. (%)
Vigna radiata				
VC 1000-C	94	0	100	2
VC 1168-B	96	0.5	100	1
VC 1482-E	84	0.6	89	0
VC 1560-D	91	0	100	1.5
VC 1628-A	96	0	100	1.5
VC 2307-A	100	0	NT	
VC 2750-A	99	1	99	0
VC 2764-A	91	0	100	1
VC 2768-B	94	0	98	0
VC 2778-A	99	2.5	100	2.5
V 1111	95	0	95	0
V 2773	90	0.6	100	0
V 3726	100	1	99	1
V. unguiculata subsp. *sesquipedalis*				
CP 1	95	0	89	0.6
CP 10	NT		94	0
CP 40	93	0	92	0
CP 44	NT		96	0.5
CP 72	92	0	96	0
V. unguiculata				
Blue Goose	92	0	88	0
Blackeye	NT		96	0
Green Pod Kaohsiung	97	0	97	0

Cucumber Mosaic Virus: Host Range, Seed Transmission, and Sources of Resistance

Introduction

Cucumber mosaic virus (CMV), previously isolated from mungbean is being further characterized and its importance determined by investigating its host range and seed transmission. Sources of resistance are also being investigated.

Materials and Methods

Twenty hosts belonging to the legume family and twelve nonlegume hosts (*Lycopersicon esculentum* cvs. CSTMW 18, Delissa, Perou 2, TK 70, and Bonnie Best, *Datura stramonium*, *Nicotiana glutinosa*, *N. benthamiana*, *N. tabacum* cvs. White Burley, Xanthi, and Samsun) were tested. Five to ten plants of each host were inoculated mechanically with a homogenate of 1 part fresh CMV-infected leaves of *N. glutinosa* in 3 parts 0.01 M phosphate buffer pH 7.0 with 0.1% thioglycollate added. Symptomless plants and those with mild symptoms were checked by ELISA.

Twelve elite breeding lines and eight AVRDC accessions representing some parents of the breeding lines, and four cowpea lines were tested for their ability to transmit CMV through seeds. Approximately 200 seeds of each line were collected from plants artificially inoculated at the primary leaf stage and sown in the greenhouse. The germinated seedlings were observed for four weeks for symptom

development. Plants with symptoms were tested individually by ELISA. Twenty random samples of symptomless plants, pooled in four groups of five, were also tested by ELISA to check for latent infection.

Thirty-six elite mungbean breeding lines and 23 AVRDC mungbean accessions representing parents of elite breeding lines were also tested. Thirty to 50 plants were tested and screened as described for host range. All symptomless plants were tested by ELISA by removing one leaf per plant and pooling these leaves into groups of five.

Results and Discussion

Of the legume hosts tested, all yard long beans (*Vigna sesquipedalis*, FTHES CP1, CP10, CP22, CP44, and CP72) and all cowpeas (*Vigna unguiculata* Early Ramshorn, Blue Goose, Green Pod Kaohsiung, TVU2480 and California Blackeye) were susceptible to CMV isolate M-48. All of the 10 soybean cultivars tested including both foreign and local cultivars (*Glycine max* TN-3, TN-4, KS 8, KS 9, HL 1, Bragg, Davis, Jupiter, Tokyo, Toyosuzu) were found to be immune to M-48.

Of the 12 nonlegume hosts, all but *D. stramonium* were susceptible. The seed transmissibility of CMV isolate M-48 in mungbean breeding lines, in some accessions, and in four cowpea lines is shown in Table 5.

Table 5. Seed transmission of CMV isolate M-48 in mungbean and cowpea.[z]

Host	% Germination	% Seed Transmission	Host	% Germination	% Seed Transmission
Vigna radiata					
VC 1000-C	98	1.5	V 1380	99	2.5
VC 1168-B	96	1.0	V 1381	95	5.8
VC 1482-E	96	0	V 1400	97	3.6
VC 1560-D	92	3.8	V 1945	91	6.0
VC 2307-A	100	0	V 1947	98	2.1
VC 2572-A	94	1.1	V 2184	99	4.6
VC 2719-A	90	2.2	V 2273	79	0.6
VC 2750-A	75	1.3	V 3726	99	1.5
VC 2778-A	99	0.5			
Vigna unguiculata					
FTHES CP 1	94	11.2	FTHES CP 40	99	0
FTHES CP 20	98	1.0	FTHES CP 44	97	1.6

[z]Of germinated plants.

In all but two of the mungbeans, isolate M-48 was found to be seed transmitted. Seed transmission ranged from 0.6 to 6% in mungbean and from 1 to 11.2% in cowpea.

The results of the resistance screening of elite breeding lines is shown in Table 6. Four lines (V 2010, V 2984, VC 2755-A, and VC 1973-A) could be identified with no systemic infection. However, these lines contained a high number of plants which reacted with local lesions on the inoculated leaves. Another four lines (V 3476, VC 2764-A, VC 2764-B, VC 2768-A) had CMV incidence of less than 15%. These lines also contained a high number of plants with necrotic local lesions on the inoculated leaves. All other lines were susceptible.

The source of resistance of these lines could not be identified, since none of their parents were found with resistance (Table 7). Three parental lines, however, represented by code nos. 14, 16, and 18 were found with a low percentage of infection (6% or less). Parental lines 14 and 16 are part of the pedigrees of VC 2755-A and VC 3012-B, two of the resistant breeding lines. Line no. 18 is the major parent of VC 2917-A. The resistance source of the other resistant breeding line VC 1973-A was probably V 3476, which had a low percentage (13%) of CMV infection. Most likely the parent or the cross was accidentally chosen from one of the resistant plants.

Table 6. Reactions of elite breeding lines to virus isolate M-48.

Breeding Line	Parentage[z]	% CMV Incidence[y]
V 2010		0 (91% NL)
V 2984		0 (96% NL)
V 3476		13 (68% NL)
V 3726		17 to 78
V 6017		19 to 88
VC 1089-A	(18/1)	58
VC 1131-A	(8/18//8)	75
VC 1562-A	(11//16/18)0-46	77
VC 1628-A	(20/15)	32 (32% NL)
VC 1973-A	(20/8)	0 (87% NL)
VC 2307-A	(22/15////5//18/2///15/2)	75
VC 2523-A	(18/6//15) 0	13 (74% NL)
VC 2720-A	(22//9/16)	62
VC 2750-A	(9/16///11//12/18)	84
VC 2755-A	(5/16///12/18//15)	0 (75% NL)
VC 2762-B	(4/17//11/16)	67
VC 2762-C	(4/17//11/16)	86
VC 2763-A	(4/17///11/12/18)	92
VC 2764-A	(4/17//20/15)	2 (7% NL)
VC 2764-B	(4/17//20/15)	7 (79% NL)
VC 2768-A	(4/18//20/15)	7 (47% NL)
VC 2768-B	(4/18//20/15)	28 (49% NL)
VC 2778-A	(11/12/18///20/15)	16 to 83
VC 2778-B	(11/12/18///20/15)	74
VC 2778-C	(11//12/18///20/15)	25 (54% NL)
VC 2802-A	(15/18//15///18/1////8/18//20)	75
VC 2917-A	(12/18//15///18/1////8/18//20)	0 (52% NL)
VC 2985-A	(8/18////17)	68
VC 2991-A	(8/18//8////7/17)	86
VC 3004-A	(9/16//22)	70
VC 3011-A	(4/17//10/16///14/18)	0 (52% NL)
VC 3012-B	(4/17//10/16///19/18)	74
VC 3029-A	(4/18///11//12/18)	89
VC 3178-A	(20//18/13)	92
VC 3301-A	(18/13///12/18//15)	100
VC 3580-A	(22////7/17//9/16)	87

[z]Expressed as code numbers. [y]Percentage of plants showing no systemic infection but necrotic lesions on the inoculated primary leaves.

One of the parents, V 3686, was identified with resistance, having no systemic infection and only a low percentage of plants with local lesions on the inoculated leaves. This line is a parent of some new breeding lines which have not yet been screened for resistance.

Conclusion

The host range of cucumber mosaic virus was found to be largely confined to the legume family. Soybeans, however, with one or two exceptions, were not infected. *Chenopodium quinoa* and *Chenopodium amaranticolor* were the only nonlegume hosts that could be infected, the latter with systemic local lesions. The virus was found to be seed-transmitted in mungbean and cowpea. Several resistant, elite breeding lines were found and the sources of resistance identified among the parental lines. In mungbean resistance seems to be associated with the appearance of necrotic local lesions on the inoculated leaves. The inheritance of resistance will be investigated in the future.

Table 7. Reactions of selected parents of elite breeding lines to CMV isolate M-48.

Code No.	Accession Numbers	% Infection	Code No.	Accession Numbers	% Infection
1	V 1066	NT	12	V 1947	100
2	V 1104	52	13	V 1948	>50[z]
3	V 1377	45	14	V 1969	5 (>80% NL)
4	V 1380	100	15	V 2184	100
5	V 1381	100	16	V 2272	5 (26% NL)
6	V 1387	76	17	V 2273	85
7	V 1394	79	18	V 2773	6 (35% NL)
8	V 1400	90	19	V 3409	<20[z]
9	V 1411	93	20	V 3476	13 (50% NL)
10	V 1944	>50[z]	21	V 3686	0 (22% NL)
11	V 1945	95	22	V 5000	93

[z]Complete data not yet recorded.

Controlling the Mungbean Root Disease Complex

Introduction

AVRDC mungbean plantings in previous years were often severely damaged by an unidentified disease or disease complex with symptoms of severe root deterioration, discoloration of the vascular tissue, stunting, and leaf chlorosis and necrosis. The condition eventually led to the death of mungbean plants. This mungbean root disease has become a serious problem at AVRDC, particularly when mungbean is grown in the cool season. Previous experiments indicated that soil fumigation with chloropicrin gave effective control, but fumigation is impractical at AVRDC. The purpose of this trial was to identify control measures that are more applicable to the AVRDC situation than chloropicrin.

Materials and Methods

The trial was planted on 15 March 1985 in the mungbean root- disease nursery in a randomized complete block design with four replications. The locally released AVRDC cultivar TN #3 was planted in this trial in 3 x 6 m plots. Rows and plant spaces were 50 cm and 10 cm, respectively, with two seeds per hill for a plant density equivalent to 200,000 plants/ha. The treatments were 1) deep plowing to a depth of 50 cm; 2) application of compost (made by the Farm Department) at a rate of 20 t/ha; 3) soil application of a mixture of benomyl 50% w.p. (3 g a.i./m^2), PCNB 75% w.p. (1.69 g a.i./m^2), captan 50% w.p. (5 g a.i./m^2), and thiram 80% w.p. (1.44 g a.i./m^2) before plowing the soil; and 4) control, normal cultural practices.

Germination percentage, percentage of damping-off at 26 days after planting (DAP) and plant survival data were collected from the middle area (2 x 5 m) in each plot. The yield, length of main root, plant height and dry weight, and number of nodules per plant were also determined in 2 x 5 m area of each plot. These data were collected from 24 May to 7 June.

Results and Discussion

Germination, ranging from 67.5 to 86.6%, was not good in any treatment (Table 8), except in the deep-plow treatment which was significantly high. Two weeks after the first evaluation, the chemical application showed the most effective protection against postemergence damping-off; deep plowing was the second most effective treatment (Table 8). Therefore, the percentage of surviving plants in the deep plowing and chemical application treatments was significantly higher than in the other treatments.

Table 8. Effect of deep plowing, compost, and chemical application on germination, damping-off, and survival of mungbean in a field infested with mungbean root pathogens[z].

Treatment	Germination 12 DAP (%)	Damping-Off 26 DAP (%)	Plt Survival 26 DAP (%)
Deep plow	86.6 a	9.3 b	77.3 a
Compost application	71.1 b	19.9 a	51.2 b
Chemical application[y]	73.6 b	0.7 c	72.9 a
Control	67.5 b	18.9 a	48.6 b
LSD 5%	9.7	5.2	8.1
1%	13.9	7.5	11.6
CV	8.1	26.8	8.1

[z]Planted: 15 March 1985; plot size: 3 x 6 m (evaluated area: 2 x 5 m). Data represent the means of four replications. [y]Benomyl, PCNB, captan, and thiram.

Plant growth, as measured by plant height and dry weight per plant, was very poor in all treatments, although the environment was suitable for mungbean growth. However, plants in the deep-plowing treatment were 59% taller and 60% heavier than in the control and significantly taller and heavier than in any other treatments (Table 9).

The main roots were very short in all treatments, ranging from 7.6 to 9.3 cm (Table 9). Most of them were also twisted and rotted. Nodule number per plant in the chemical application was much lower than in other treatments. Most probably, the chemical residue affected the Rhizobium and/or the formation of nodules. The chemical application treatment showed the lowest plant weight which was only 48% of the deep-plow treatment.

The results of the yield were different only in the deep-plow treatment (Table 10). The yields of the first and the second harvests in the deep-plow treatment were higher than in the other treatments, and its total yield was significantly better then that of the control. This is because more and taller plants survived.

Deep plowing promoted plant growth in a field infested with pathogens associated with the root disease complex. It was, therefore, partially effective in controlling the disease. Although the application of benomyl, PCNB, captan, and thiram was the most effective in controlling postemergence damping-off, the residue affected mungbean growth and nodule formation, resulting in the poorest yield.

Conclusion

Deep plowing was the best treatment for promoting plant growth in a field infested with pathogens associated with the root disease complex. However, only partial control was obtained, indicating that additional studies are necessary.

Table 9. Effect of deep plowing, compost, and chemical application on agronomic characters of mungbean at harvest in a field infested with mungbean root pathogens.[z]

Treatment	Plt Ht (cm)	Length of Main Rt (cm)	No. of Nodules	Dry Wt/Plt (g)
Deep plowing	25.4	7.6	21.9	7.7
Compost application	16.2	8.1	18.9	5.2
Chemical application[y]	13.5	9.3	6.1	3.6
Control	16.0	8.2	25.2	4.8
LSD 5%	4.4	1.4	7.9	1.5
1%	6.4	2.0	11.4	2.1
CV	15.5	10.2	27.5	17.2

[z]Planted: 15 March 1985; plot size: 3 x 6 m (evaluated area: 2 x 5 m). Data represent the means of four replications. [y]Benomyl, PCNB, captan, and thiram.

Table 10. Effect of deep plowing, compost, and chemical application on the yield of mungbean in a field infested with mungbean root pathogens.[z]

Treatment	1st Harvest ($g/10\ m^2$)	2nd Harvest ($g/10\ m^2$)	Total Yield ($g/10\ m^2$)
Deep plow	509.5	365.5	875.0
Compost application	449.0	104.5	553.5
Chemical application[y]	330.3	168.8	499.0
Control	411.0	114.0	525.0
LSD 5%	348.1	113.7	302.0
1%	500.1	163.4	433.9
CV	51.2	37.8	30.8

[z]Planted: 15 March 1985; plot size: 3 x 6 m^2 (harvested area: 2 x 5 m). Data represent the means of four replications. [y]Benomyl, PCNB, captan, and thiram.

Mungbean Physiology

The Role of Plant Hormones in the Uniform Maturity of Mungbean

Introduction

The mungbean crop does not usually mature uniformly, and so growers have to harvest more than once. However, there are several improved breeding lines that tend to mature uniformly. It was observed earlier that mungbean pods mature rapidly and uniformly right after a certain period of continuous artificial shedding of newly formed flower buds. The results seem to suggest that the balance of certain endogenous plant hormones is responsible for uniform maturity. This study examined the change of endogenous plant hormones during the flowering and pod- developing stages of uniform and nonuniform varieties with or without artificial shedding of flower buds, and correlated the findings with maturity.

Materials and Methods

Materials of VC 1628-A (uniform maturing) and V 1067-B (non-uniform maturing) were sown on 12 March 1985. Seeds were sown directly in double-row beds (1 m x 5 m). Spacing was 5 cm between hills and 50 cm between rows. Each entry was given two treatments: 1) control without deflowering, and 2) deflowering of all flowers for 10 days, starting from 30 April 1985. A randomized complete block design with three replicates was employed. Twenty plants of each plot were randomly selected and the xylem sap collected three times at two-week intervals starting from the beginning of flowering. On the day of sap collection, the plant was cut at the point below the unifoliate leaf node. The sap was continuously collected for 18 hours and analyzed for endogenous IAA, GA_3, and ABA. Since IAA was not detected in this experiment, the results are not discussed here. At the time of cutting for sap collection, the top part of the plant was measured for fresh and dry weight and the leaf analyzed for starch content.

Results and Discussion

Of the undeflowered plants, nonuniform V 1067-B had more vigorous shoot growth than uniform VC 1628-A (Table 1). This vigorous shoot growth seemed to compete with the reproductive growth for photosynthate, thereby prolonging the maturity of V 1067-B. Based on number of mature pods harvested at different stages after planting, deflowering tended to narrow the maturity period of developing pods of both varieties (Fig. 1). Deflowering also tended to increase shoot growth and reproductive growth when they were measured at earlier stages. However, the extent of shoot growth increment in the period between first anthesis and two weeks after anthesis was less in the deflowered than in the undeflowered group.

As shown in Table 1, the magnitude of shoot growth at 2 to 4 weeks after anthesis was greater in V 1067-B than in VC 1628-A. Both the results support the speculation that the competition of photosynthates may interfere with plant maturity.

Data in Table 1 also show that V 1067-B produced more xylem sap than VC 1628-A. This may be a reflection of the former's vigorous vegetative growth. Deflowering also increased xylem sap production in both entries. Since this sap is a source of mineral elements, amino acid, and plant

Table 1. Effect of deflowering (df) on growth and xylem sap efflux of two mungbean varieties.

Stages	VC 1628-A		V 1067-B	
	ck	df	ck	df
Dry weight of vegetative top (g/plant)				
Anthesis	3.65c[z]	7.19b	4.83b	7.89c
2 WAA[y]	7.17ab	9.86a	13.13a	13.24b
4 WAA	8.37a	10.23a	13.50a	17.60a
Dry weight of reproductive organ (g/plant)				
Anthesis	0.12c	0.19b	0.11c	0.21b
2 WAA	5.58b	8.33a	4.28b	8.01a
4 WAA	9.61a	8.20a	10.56a	11.92a
Volume of xylem sap collected (ml/plant)				
Anthesis	2.50	6.32a	2.59b	8.92
2 WAA	1.92	4.31ab	3.52ab	5.28
4 WAA	1.97	2.51b	6.65a	5.70
Leaf starch content (%)				
Anthesis	11.30a	12.36a	4.70ab	6.27
2 WAA	5.23b	8.53ab	5.30a	5.43
4 WAA	6.15b	4.79b	3.70b	3.93

[z]Mean separation within columns by Duncan's multiple range test, 5% level. [y]WAA = weeks after anthesis

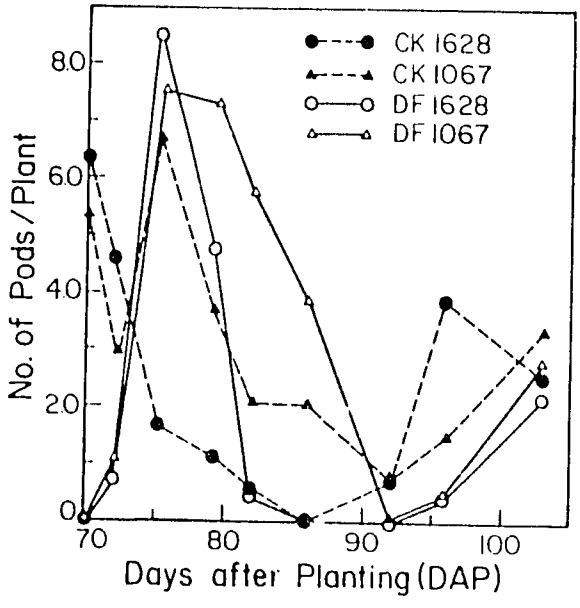

Fig. 1.
Number of mature pods harvested at different stages of mungbean growth.

Table 2. Total hormonal content in the xylem sap (μg/18 h of collection) of two mungbean varieties.

Stages/ Entries	GA_3		ABA	
	ck	df[z]	ck	df
Anthesis				
VC 1628-A	8.35	13.23	1.79	3.73
V 1067-B	9.54	13.09	2.91	4.34
2 WAA				
VC 1628-A	22.66	21.15	2.11	1.73
V 1067-B	19.12	17.95	1.98	2.30
4 WAA				
VC 1628-A	17.68	18.04	0.67	1.00
V 1067-B	25.30	25.70	2.08	1.80

[z]df = deflowering.

hormones, the quality and profile of components would play an important role in the balance of vegetative and reproductive growth.

Data in Table 2 show that total GA_3 content increased from anthesis up to two weeks after anthesis (WAA), before they decreased in both treatments of VC 1628-A. In V 1067-B, GA_3 content steadily increased from anthesis to four weeks after anthesis in both treatments. However, deflowering tended to increase both GA_3 and ABA at the anthesis stage. Whether this increase has any role in the uniform maturity of mungbean will be determined at the culmination of the study. However, based on the application of growth regulators, they seem to do so.

The analysis of starch content in the leaf revealed that VC 1628-A contained a higher level of starch especially at anthesis. Deflowering tended to increase starch content in the leaves of both cultivars in the early reproductive stage. High starch content in the leaf should provide a good source of photosynthates for the developing pod. High GA_3 and/or ABA may be used to mobilize the starch in the leaf for the developing pod.

Conclusion

Uniformly maturing VC 1628-A had a larger amount of GA_3 in the xylem sap collected at 2 WAA when the major pod development was in progress. However, a large increase of GA_3 occurred at 4 WAA in nonuniform V 1067-B which might imply the dispersed process of pod development. Leaves of VC 1628-A also contained a high concentration of starch. The results seem to suggest that high amounts of GA_3 are used to mobilize the starch in the leaf for the developing pods, thereby enhancing uniform maturity. Deflowering increased the starch content of leaves and hormone content of xylem sap mostly in the early reproductive stage.

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Soybean Breeding

Hybridization Program

Introduction

Hybridization is done to add desirable characters to a superior cultivar or a selection which lacks them. Through hybridization new combinations of genes are expected which can be selected in succeeding generations, provided appropriate selection methods are employed.

Materials and Methods

Twenty accessions with desirable characters, such as resistance/tolerance to diseases and insects, were crossed with five promising AVRDC *Glycine* selections (AGS) to make further improvements. Fifty-five F1's with parents which are resistant to diseases and insects were intercrossed and also backcrossed to their parents.

Results and Discussion

To combine resistance/tolerance to rust, soybean mosaic virus, bacterial pustule, and defoliating insects, 360 crosses were made. In order to improve the yield potential of vegetable soybeans, two crosses were made. Eight other crosses were made to accomplish additional objectives. The 360 crosses and their objectives are as follows:

Backcross or cross for resistance to rust	317
Backcross for resistance to SMV	2
Backcross for resistance to bacterial pustule	20
Backcross or cross for resistance to defoliator	11
Improvement of vegetable soybean	2
Backcross for narrow leaf	2
Backcross for insensitivity to photoperiod	1
Backcross for inheritance of G 9053 podding type	3
Inheritance of AGS 2 flowering	2
Total	360

Intercrosses among F1's were made to develop recurrent populations for yield and disease or insect resistance. The majority of the backcrosses were made to study the genetic behavior of the traits. In other cases backcrosses were aimed at increasing the contribution of the recurrent parent genes.

Conclusion

A total of 360 crosses were made to combine high yield with disease and/or insect resistance. They will be used in a selection program or for further intermating to develop new recurrent populations.

Screening for Photoperiodic Response

Introduction

Adaptability of a photoperiod-sensitive variety is restricted to a narrow range of latitude and invariably to a specific season. If photoperiod-insensitive genotypes could be found in soybean, it would enable the development of soybean varieties with a wider latitudinal range of adaptation.

Materials and Methods

A total of 30 entries were planted on 4 March 1985 in a split-plot design with four treatments (10 h, 12 h, 14 h, and 16 h photoperiod) and two replications. The entries included 28 new accessions collected from India, G 215 (photoperiod-insensitive check), and G 2120 (photoperiod-sensitive check). The artificial light for the extended photoperiod treatments consisted of a mixture of incandescent light and Gro-lux lamps (the light intensity was 55 to 60 microeinsteins/sq cm PAR). The treatment commenced soon after emergence.

Results and Discussion

All the entries matured in 81 to 98 days in the 10 h treatment. Five accessions matured in 121 to 148 days in the 12 h treatment. Four entries in the 14 h treatment and 28 entries in the 16 h treatment did not flower till 150 days after planting when the experiment was terminated. Only G-187 and G 215 matured in all photoperiod treatments within 87 to 106 days (Table 1).

Table 1. Six accessions less sensitive to photoperiod selected from 30 new accessions planted in 1985, AVRDC.

Cultivar	Days to Flowering[z]				Days to Maturity				Yield (g/plant)			
	10[z]	12	14	16	10	12	14	16	10	12	14	16
G-187	37	44	44	49	89	104	85	104	2.6	2.5	2.7	3.9
MACS-42	43	60	71	–[y]	92	148	–	–	4.7	10.7	–	–
MACS-66	44	62	75	–	87	142	–	–	4.2	12.2	–	–
MACS-51	45	62	64	–	85	132	–	–	2.9	5.2	–	–
MACS-56	46	61	81	–	93	145	–	–	4.1	13.5	–	–
MACS-128	47	54	60	–	90	121	–	–	2.1	4.3	–	–
G 215 (Ck1)	43	44	44	55	87	98	86	106	2.6	2.7	2.3	3.8
G 2120 (Ck2)	53	116	85	–	98	–	–	–	3.1	–	–	–

[z]Photoperiod treatment (h). [y]The plant did not flower or mature when the trial was terminated 150 days after planting

Conclusion

Twenty-eight new accessions and two checks were screened for photoperiodic response. One accession was identified as photoperiod-insensitive and its yield potential will be evaluated in 1986.

Breeding for Nonbeany Flavor

Introduction

Soybean protein products are limited due to undesirable flavor. Lipids are a major source of compounds responsible for this objectionable flavor. Lipoxygenase is a plant enzyme that catalyzes the oxidation of various unsaturated fatty acids. Soybean seed lipoxygenase catalyzes lipid oxidation as the critical first step in the formation of these undesirable flavor compounds.

Materials and Methods

One hundred and thirty-seven F2 breeding lines derived from crosses involving one parent null for lipoxygenase were analyzed by the Chemistry Department. Ichigou Wasedaizu (G 2637) and Wase natsu (G 2891) were used as lipoxygenase null checks. From each line a sample of 10 seeds were evaluated. The lipoxygenase electrophoresis technique is as follows:

1. Lipoxygenase was extracted from soybean seed by grinding 100 mg soybean seed in 3 ml buffer (0.06 M Tris., 0.015 M $CaCl_2$, 13% sucrose, pH 8.2). The extracts were centrifuged at 3000XG at 4°C for 15 min.

2. The electrophoresis of seed extracts (50 μl on 10% polyacrylamide) was performed according to the method of Davis but at pH 8.3. The current was 2.5 mA/gel.

3. The staining buffer contained 3.5 x 10^{-3} M linoleic acid, 15% (v/v) ethanol, 0.1 M sodium borate buffer pH 9.0, 10^{-3} M KCN and 0.02% (w/v) O-dianisidine. Incubation time was 4 h.

Results and Discussion

Out of 137 F2 lines screened, 13 F2 lines had similar lipoxygenase rating as that of G 2637 and G 2891. The following are the 13 F2 lines without lipoxygenase with their pedigrees:

GC 84150-21	Wase natsu x TK 5
GC 84151-3	Wase natsu x G 2120 M_7 (20-4)
GC 84151-7	Wase natsu x G 2120 M_7 (20-4)
GC 84152-21	Wase natsu x G 2120 M_7 (57-1-5)
GC 84155-4	Ichigou Wasedaizu x TK 5
GC 84156-17	Ichigou Wasedaizu x G 2120 M_7 (20-4)
GC 84157-1	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-2	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-9	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-10	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-18	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-31	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)
GC 84157-35	Ichigou Wasedaizu x G 2120 M_7 (57-1-5)

Among those, four of them were crossed with G 2891 and nine of them, with G 2637.

Conclusion

Assuming that lipoxygenase is one of the factors causing the objectionable beany flavor, crosses were made to eliminate it. From preliminary results it appears that selecting genotypes null for lipoxygenase from a segregating population can be a routine process. The 13 selections will be evaluated for yield and other desirable characteristics.

Advanced Yield Trials

Introduction

Selections from intermediate yield trials (IYT) are entered in advanced yield trials (AYT) where outstanding selections from the AYT's will be included in the AVRDC Soybean Evaluation Trials (ASET)

Materials and Methods

Fifty AGS lines were evaluated in four AYT's in autumn 1984 (AYT-I, 13 lines; AYT-II, 11 lines; AYT-III, 12 lines, AYT-V, 14 lines) which were not reported last year. AYT-V was also evaluated

in paddy fields without land preparation at AVRDC (3 October 1984) and in Ping-tung (11 October 1984 planted in rice-stubble culture). Shih Shih, TN #15, AGS 181, and AGS 182 served as checks for AYT-I, AYT-II, and AYT-III. Shih Shih, TK #5, AGS 181, and AGS 182 were used as checks for AYT-V.

A total of thirty one AGS lines were evaluated in two AYT's in 1985 (AYT-I, 16 lines; AYT-II, 15 lines). AGS 129 and AGS 181 served as checks. The experiments were conducted in a randomized complete block design with four replications. The AVRDC suggested cultural practices were used and major agronomic characters were recorded.

Results and Discussion

AGS 239, 261, and 265 were significantly higher-yielding than the high-yielding check cultivars of the September 1984 trial (Table 2). These three lines have high levels of tolerance to soybean rust with AGS 261 also resistant to downy mildew.

Table 2. High-yielding lines selected from advanced yield trials (AYT) planted in September 1984.

Entry No.	Cross Designation	Yield (t/ha)	Days to Maturity	Remarks[z]
AYT-I				
AGS 239	GC 50047-1-12-8-6-1	1.7 a[y]	89	SR
AGS 181 (Ck)		1.4 bcd	73	SR, DM
G 38 (Ck)		1.2 cde	78	DM
AYT-II				
AGS 276	G 2120-97RR-1	1.4 a	79	SR
AGS 249	GC 60082-8-9-6-7	1.4 ab	86	SR, DM
AGS 244	GC 60034-4-6-6-10	1.4 ab	81	
AGS 182 (Ck)		1.3 ab	75	SR,DM
AYT-II				
AGS 261	GC 50030-4-3-6-6-6	1.7 a	89	SR, DM
AGS 265	GC 60031-2-7-6-6	1.6 ab	83	SR
AGS 181 (Ck)		1.2 cde	75	SR, DM
G 38 (Ck)	1.1 de	77	DM	

[z]SR = soybean rust tolerance similar to AGS 181. DM = resistant to downy mildew. [y]Means within columns followed by the same letter are not significantly different at the 5% level.

In AYT-V the mean yields of the entries without tillage at AVRDC and Ping-tung were, respectively, 47% and 90% higher than those of the tillage plots at AVRDC. AGS 281, 285, 286, and 288 were higher yielding than the check cultivars in both tilled and untilled plots (Table 3). The correlation between yields in both tilled and untilled plots at AVRDC was significant (r = 0.489) but was insignificant at Ping-tung (r = 0.201 NS), suggesting a strong genotype-environment interaction.

A combined analysis of AYT's in three seasons was done to determine varietal adaptation. The regression coefficients of AGS 239, 255, 260, 261, 262, 265, 285, and 288 were close to 1.0 and they had a high mean yield, suggesting that they have a fairly wide adaptability to different seasons (Figs. 1 to 4).

All the AYTm8 (advanced yield trial of mutant 8) lines were significantly lower-yielding than the high-yielding check cultivar (AGS 129) in both the February and July plantings, but all the lines matured in 103 to 107 days (February) and 87 to 88 days (July) which are earlier than in AGS 129. AGS 299 was on par in yield with AGS 129 in the February and July 1985 plantings. It was also resistant to downy mildew (Table 4).

Upon completion of the trial planted in September, a combined analysis of all the three seasons will be done to evaluate the adaptability to more than one season.

Table 3. High-yielding lines selected from AYT-V with different planting methods in two places, 1984.[z]

Entry No.	Cross Designation	AVRDC[y] with tillage		AVRDC[x] without tillage		Ping-tung[w] without tillage	
		yield(t/ha)	DM[v]	yield(t/ha)	DM	yield(t/ha)	DM
AGS 286 GC	60066-106A-6-7-6-11	1.7 a	88	2.7 a	92	2.9 ab	93
AGS 285	GC 60066-87A-16-2-7-6-6-10	1.7 a	87	2.4 ab	90	3.2 a	87
AGS 288	GC 50106-47-6 6-6	1.6 abc	88	2.3 abc	93	2.8 ab	91
AGS 281	GC 50265-2-9-6-8	1.6 abc	89	2.3 abc	95	2.8 ab	87
AGS 181 (Ck1)		1.4 a-e	75	2.0 bcde	81	–	–
Shih Shih (Ck2)		1.2 def	78	1.9 cde	82	2.7 bc	83
TK 5 (Ck3)		1.0 ef	86	2.2 bcd	88	3.1 ab	85

[z]AYT-V = advanced yield trial V. [y]Planting duration: 13 Sept. to 17 Dec. 1984. [x]Planting duration: 3 Oct. 1984 to 8 Jan. 1985. [w]Planting duration: 11 Oct. 1984 to 12 Jan. 1985. [v]DM = days to maturity.

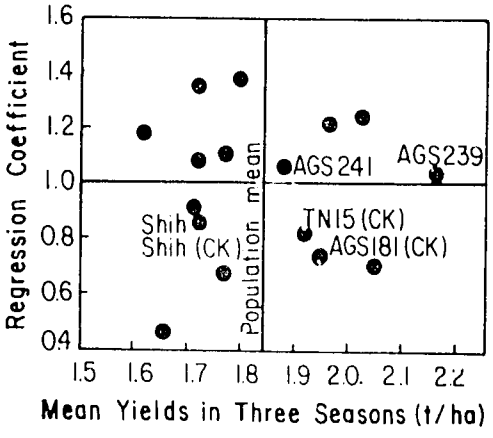

Fig. 1. The relationship of mean yield and stability parameter (regression coefficient) of lines grown in three seasons in the advanced yield trial-I, 1984.

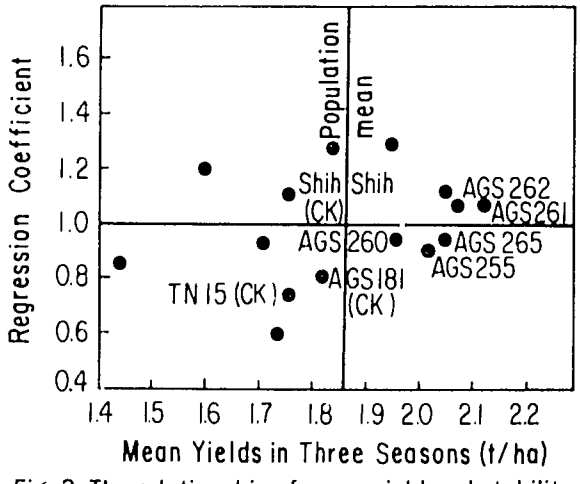

Fig. 3. The relationship of mean yield and stability parameter (regression coefficient) of lines grown in three seasons in the advanced yield trial-III, 1984.

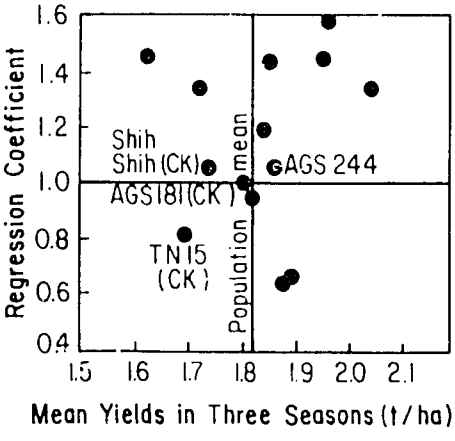

Fig. 2. The relationship of mean yield and stability parameter (regression coefficient) of lines grown in three seasons in the advanced yield trial-II, 1984.

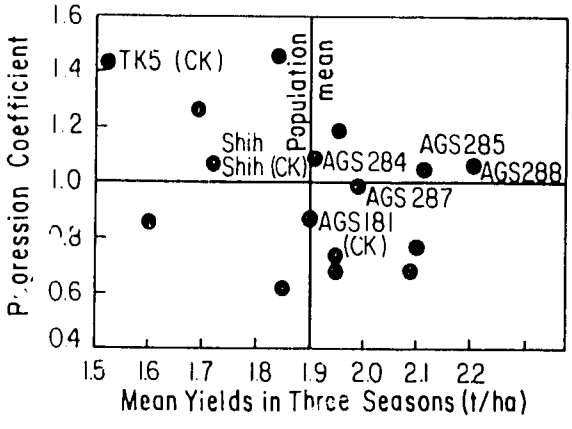

Fig. 4. The relationship of mean yield and stability parameter (regression coefficient) of lines grown in three seasons in the advanced yield trial-V, 1984.

Table 4. High-yielding lines selected from AYT-I, 1985.[z]

Entry No.	Cross Designation	Yield (t/ha)		DM[y]		Remarks[x]
		Feb.	July	Feb.	July	
AGS 299	GC 60011-4-6-13-7	2.9 ab	3.3 a	109	94	DM
AGS 129 (Ck)		3.1 a	3.3 a	106	93	DM, BP
AGS 181 (Ck)		2.7 bc	1.9 c	94	79	DM

[z]AYT-I = advanced yield trial-I. [y]DM = days to maturity. [x]DM = resistant to downy mildew; BP = resistant to bacterial pustule.

Conclusion

Several high-yielding disease-resistant AGS lines have been identified for inclusion in next ASET.

Preliminary and Intermediate Yield Trials, Spring and Summer 1985

Introduction

Promising breeding lines undergo preliminary yield trials (PYT) and then intermediate yield trials (IYT). Both PYT's and IYT's are conducted in February (spring season), July (summer season), and September (autumn season) in the same year. Breeding lines selected from IYT's are then entered in advanced yield trials (AYT's). September planting (autumn season) is not included in this report, since the experimental results are yet to be analyzed.

Materials and Methods

The PYT's were conducted in two groups while the IYT's had only one group. The PYT's were planted on 27 February in spring, and on 11 and 12 July 1985 in summer. The IYT was planted on 15 February and 11 July 1985 in spring and summer, respectively. A split-plot design was used in the 1985 PYT's and IYT's of the spring and autumn seasons. The main plot consisted of treatments with and without fungicide; and subplots were genotypes. Plot sizes for the PYT's and IYT's were 3 m x 1 m and 3 m x 2 m, respectively. The PYT's had two rows per plot while the IYT's had four rows, and both trials had two replications each.

For the fungicide treatment, Dithane M-45 was sprayed from 9 April 1985 when some entries reached the R1 growth stage. Thereafter, six additional sprays were given on 11, 17, 22 April and 7, 10, 15 May for both trials on fungicide-treated plots. Standard AVRDC cultural practices were followed. Data for all the agronomic characters in PYT's and IYT's were collected and analyzed. Selections of breeding lines were based on yield, resistance or tolerance to disease, days to maturity, and adaptability to more than one season. Since the soybean rust infection in summer was not serious, a randomized complete block design (RCBD) was used for both PYT's and IYT's.

Results and Discussion

Spring season. Among the PYT entries planted in February, there were nine breeding lines with high yields ranging from 3.6 t/ha to 4.4 t/ha compared to check lines whose yields ranged from 1.3 t/ha to 3.5 t/ha (Table 5). In PYT-II, none of the new breeding lines were higher-yielding than the high-yielding check AGS 129; but three breeding lines had higher yields than the other three checks (Table 6).

In PYT-I, breeding lines GC 90004-13 (Shih Shih x Tainung #3) and GC 50265-2-9-6-8-75 (BM43 x Tainung #3) had significantly higher yields than AGS 129 under soybean rust stress, but the yield with fungicide was not significantly different from this check (Table 7). In relation to soybean rust

Table 5. Mean yield of high-yielding genotypes in the preliminary yield trial-I (PYT-I) with and without fungicide, spring 1985.

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)
GC 90004-13	4.4	103	19.4
GC 50265-2-9-6-8-75	4.2	104	17.5
GC 90001-66	3.8	106	17.5
GC 00138-29	3.7	105	14.9
GC 50227-5-22-6-9-20	3.6	99	20.2
GC 60031-2-7-7-20	3.6	104	14.4
GC 50259-2-19-6-7-29	3.6	97	20.0
GC 50227-5-22-6-9-48	3.6	99	20.5
GC 60031-2-7-7-15	3.6	103	14.3
AGS 129 (Ck)	3.5	101	14.2
AGS 181 (Ck)	2.5	84	12.6
G 8587 (Ck)	2.4	120	15.6
G 5422 (Ck)	1.3	93	21.4
Mean of 100 entries	2.96	102	15.7
CV (%)	14.79	2.77	6.24
LSD (.01)	0.79	5.14	1.78
(.05)	0.60	3.91	1.36

Table 6. Mean yield of high-yielding genotypes in the preliminary yield trial-II (PYT-II) with and without fungicide, spring 1985.

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)
AGS 129 (Ck)	3.8	96	13.8
GC 82146-43-9-11	3.4	94	17.1
GC 82146-43-9-9	3.3	99	17.9
GC 82200-7-12-19	3.0	94	14.6
AGS 154 (Ck)	2.6	95	11.8
G 215 (Ck)	2.3	81	14.8
AGS 181 (Ck)	2.1	81	11.4
Mean of 16 entries	2.54	89	14.0
CV (%)	21.77	2.74	5.75
LSD (.01)	1.08	4.73	1.57
(.05)	0.79	3.51	1.16

tolerance, the checks used had an 8% yield increase; 12, 29, and 33% yield reduction without fungicide; and ranks of 1, 2, 6, and 8 in tolerance. Breeding lines GC 90004-13, GC 50265-2-9-6-8-75, GC 90086-51, and GC 00138-29 had a tolerance rating ranging from 3 to 7 with yields as high as AGS 129 or better.

One-hundred-seed weight is one of the key yield components influenced by soybean rust disease. On this basis, the check cultivars ranked 2, 4, 8, and 9 in soybean rust tolerance. There were three breeding lines which ranked 1 and 3 (Table 8).

Soybean rust infection is known to hasten the maturity of soybean. In the check cultivars maturity duration was reduced by 2, 10, 12, and 16 days. In four breeding lines the maturity duration was reduced by 3 to 5 days (Table 9).

The reduction of 100-seed weight due to rust accounted for 19.5% of the variability in yield loss. However, the effect of days to maturity on yield loss was not significant ($r^2 = 0.002$).

In PYT-II, none of the entries performed significantly better in yield than the high-yielding check AGS 129 either with or without fungicide. However, there appeared to be significant differences in

Table 7. Yield of breeding lines in the preliminary yield trial-I (PYT-I) with and without fungicide, spring 1985.

Cross Designation	Yield (t/ha) with fung.	Yield (t/ha) without fung.	X[z]	Y[y]	Rank[x]
GC 90004-13	5.0	3.8	1.2	24	4
GC 50265-2-9-6-8-75	4.8	3.7	1.1	23	3
GC 50227-5-22-6-9-20	4.7	2.6	2.1	45	9
GC 50227-5-22-6-9-21	4.5	2.3	2.2	49	10
GC 00051-14	4.5	2.3	2.2	49	10
GC 00073-33	4.5	2.2	2.3	51	11
GC 00138-29	4.4	3.1	1.3	30	7
GC 90086-51	4.3	2.5	1.2	28	5
GC 50227-5-22-6-9-32	4.3	2.6	2.3	53	12
GC 50227-5-22-6-9-54	4.3	2.7	2.4	56	13
AGS 129 (Ck)	4.2	2.8	1.4	33	8
G 8587 (Ck)	2.8	2.0	0.8	29	6
AGS 181 (Ck)	2.6	2.3	0.3	12	2
G 5422 (Ck)	1.2	1.3	-0.1	-8	1
Mean of 100 entries	3.50	2.42	1.08	31	
CV (%)	14.79	14.79			
LSD (.01)	1.13	1.13			
(.05)	0.86	0.86			

[z]Yield reduction due to soybean rust or yield increase with fungicide spray. [y]Yield reduction percentage due to soybean rust or yield increase percentage with fungicide spray. [x]Ranking according to soybean rust tolerance. 1 highly tolerant, increasing numbers represent decreasing tolerance.

Table 8. One-hundred-seed weight of breeding lines in the preliminary yield trial-I (PYT-I) with and without fungicide, spring 1985.

Cross Designation	100-Seed Weight (g) with fung.	100-Seed Weight (g) without fung.	X[z]	Y[y]	Rank
GC 90004-13	21.7	17.1	4.6	21	8
GC 50265-2-9-6-8-75	18.3	16.7	1.6	9	1
GC 50227-5-22-6-9-20	22.2	18.2	4.0	18	6
GC 50227-5-22-6-9-21	21.6	18.7	2.9	13	3
GC 00051-14	15.4	12.5	2.9	19	7
GC 00073-33	14.2	11.2	3.0	21	8
GC 00138-29	16.0	13.9	2.1	13	3
GC 90086-51	19.0	15.6	3.4	18	6
GC 50227-5-22-6-9-32	21.5	17.9	3.6	17	5
GC 50227-5-22-6-9-54	22.3	18.5	3.8	17	5
AGS 129 (Ck)	16.0	12.3	3.7	23	9
G 8587 (Ck)	17.0	14.2	2.8	16	4
AGS 181 (Ck)	13.3	12.0	1.3	10	2
G 5422 (Ck)	24.0	18.9	5.1	21	8
Mean of 100 entries	16.9	14.5	2.4	14	
CV (%)	6.24	6.24			
LSD (.01)	2.52	2.52			
(.05)	1.92	1.92			

[z]Seed weight reduction due to rust or seed weight increase due to fungicide treatment.
[y]Percentage of seed weight reduction due to rust or fungicide treatment.

the level of tolerance to soybean rust in some breeding lines. For example, in AGS 154 there was no yield difference at all between fungicide-protected and unprotected plants (Table 10). Similarly on 100-seed weight, some genotypes had no differences between treatments, suggesting that yield reduction due to rust occurred because of factors other than 100 seed weight (Table 11).

Table 9. Days to maturity of breeding lines in the preliminary yield trial-I (PYT-I) with and without fungicide, spring 1985.

Cross Designation	With Fungicide	Without Fungicide	Hastening of Maturity due to Rust (days)
GC 90004-13	105	101	4
GC 50265-2-9-6-8-75	106	103	3
GC 50227-5-22-6-9-20	103	95	8
GC 50227-5-22-6-9-21	101	95	6
GC 00051-14	111	99	12
GC 00073-33	106	98	8
GC 00138-29	108	103	5
GC 90086-51	104	95	9
GC 50227-5-22-6-9-32	101	96	5
GC 50227-5-22-6-9-54	101	95	6
AGS 129 (Ck)	107	95	12
G 8587 (Ck)	128	112	16
AGS 181 (Ck)	85	83	2
G 5422 (Ck)	98	88	10
Mean of 100 entries	105	98	7
CV (%)	2.77	2.77	
LSD (.01)	7.26	7.26	
(.05)	5.53	5.53	

Table 10. Yield of breeding lines in the preliminary yield trial-II (PYT-II) with and without fungicide, spring 1985.

Cross Designation	Yield (t/ha) with fung.	Yield (t/ha) without fung.	X[z]	Y[y]
AGS 129 (Ck)	4.6	2.9	1.7	37
GC 82146-43-9-11	3.7	3.2	0.5	14
GC 82146-43-9-9	3.7	2.9	0.8	22
GC 82200-7-12-19	3.3	2.7	0.6	18
GC 82200-7-12-14	3.2	2.5	0.7	22
GC 82200-6-13-10	3.0	2.2	0.8	27
AGS 154 (Ck)	2.6	2.6	0.0	0
G 215 (Ck)	2.5	2.2	0.3	12
AGS 181 (Ck)	2.2	2.0	0.2	9
Mean of 10 entries	2.8	2.3	0.5	18
CV (%)	21.77	21.77		
LSD (.01)	1.52	1.52		
(.05)	1.13	1.13		

[z]Seed weight reduction due to rust or seed weight increase due to fungicide treatment.
[y]Seed weight reduction percentage due to rust or fungicide treatment.

In PYT-II days to maturity was only slightly affected by soybean rust (Table 12). The reduction in 100-seed weight accounted for 33.1% of the variability in yield loss. However, the effect of days to maturity on yield loss was not significant (r^2 = 0.2). There were significant yield differences between genotypes in both fungicide and nonfungicide treatments in PYT-I and PYT-II (Tables 7 and 10); so that, we can choose high-yielding lines either with or without fungicide treatment.

Table 11. One-hundred-seed weight of breeding lines in the preliminary yield trial-II (PYT-II) with and without fungicide, spring 1985.

Cross Designation	100-Seed Weight (g)		X[z]	Y[y]
	with fung.	without fung.		
AGS 129 (Ck)	14.8	12.7	2.1	14
GC 82146-43-9-11	17.5	16.7	0.8	5
GC 82200-7-12-9	18.1	17.6	0.5	3
GC 82200-7-12-19	14.6	14.5	0.1	1
GC 82200-7-12-14	16.2	16.2	0.0	0
GC 82200-6-13-10	15.2	14.8	0.4	3
AGS 154 (Ck)	11.7	11.4	0.3	3
G 215 (Ck)	14.8	14.6	0.2	1
AGS 181 (Ck)	11.9	11.0	0.9	8
Mean of 16 entries	14.4	14.0	0.4	3
CV (%)	5.74	5.74		
LSD (.01)	2.22	2.22		
(.05)	1.65	1.65		

[z]Seed weight reduction due to rust or seed weight increase due to fungicide treatment. [y]Seed weight reduction percentage due to rust or fungicide treatment

Table 12. Days to maturity of breeding lines in the preliminary yield trial-II (PYT-II) with and without fungicide, spring 1985.

Cross Designation	Days to Maturity		Hastening of Maturity due to Rust (days)
	with fung.	without fung.	
AGS 129 (Ck)	98	94	4
GC 82146-43-9-11	95	94	1
GC 82146-43-9-9	99	99	0
GC 82200-7-12-19	95	93	2
GC 82200-7-12-14	94	92	2
GC 82200-6-13-10	91	8[illegible]	2
AGS 154 (Ck)	95	95	0
G 215 (Ck)	81	81	0
AGS 181 (Ck)	81	80	1
Mean of 16 entries	90	88	2
CV (%)	2.74	2.74	
LSD (.01)	6.69	6.69	
(.05)	4.97	4.97	

In the IYT-I spring season, two breeding lines GC 60058-12-6-6-1-39 and GC 60058-12-6-6-1-55 were significantly higher yielding without fungicide treatment than the check, AGS 129 (Table 13). The soybean rust ranking, however, was much better in the four breeding lines than in the check cultivars.

The reduction in 100-seed weight accounted for 33.5% of the variability in yield loss in PYT-II. However, the effect of days to maturity on yield loss was not significant (r^2 0.20).

Summer season. In PYT-I, PYT-II, and IYT-I, there were no breeding lines which were higher-yielding than the check AGS 129 (Tables 14, 15, and 16). Under this circumstance, selection was focused on breeding lines with good levels of bacterial pustule resistance which were observed in PYT-I and PYT-II. Similarly in IYT-I, three breeding lines had good levels of resistance to this disease.

Conclusion

A number of promising selections have been chosen from the PYT's and IYT's to be advanced to the next evaluation stage.

Table 13. Yield of breeding lines with and without fungicide in the intermediate yield trial-I (IYT-I), spring 1985.

Cross Designation	Yield (t/ha) with fung.	Yield (t/ha) without fung.	X[z]	Y[y]	Tolerance Ranking[x]
GC 60087-7-6-9-8E-38	3.4	2.5	0.9	26	6
GC 60058-12-6-6-1-39	3.4	3.3	0.1	3	1
GC 60058-12-6-6-1 55	3.3	2.8	0.5	15	3
GC 60115-6-6-6-7-94	3.2	2.0	1.2	38	8
GC 60058-12-6-6-1-67	3 0	2.7	0.3	10	2
GC 60115-6-6-6-7-18	3.0	2.5	0.5	17	4
AGS 129 (Ck)	2.9	2.0	0.9	31	7
AGS 181 (Ck)	2.8	2.3	0.5	18	5
Mean of 28 entries	2.6	2.1	0.5	19	
CV (%)	15.8	15.8			
LSD (.01)	0.98	0.98			
(.05)	0.73	0.73			

[z]Yield reduction due to soybean rust or yield increase with fungicide spray. [y]Yield reduction percentage due to soybean rust or yield increase percentage with fungicide spray. [x]Ranking according to soybean rust tolerance 1 highly tolerant, increasing numbers represent decreasing tolerance.

Table 14. High-yielding genotypes in the preliminary yield trial-I (PYT-I), summer 1985.

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)	Remark[z]
AGS 129 (Ck)	4.3	97	15.3	BP
GC 60037-1-6 6-13-6	3.8	107	12.8	
GC 90080 14	3.7	97	9.9	BP
GC 00133-47	3.6	100	12.0	
GC 00062-135	3.6	105	12.4	BP
GC 00070-110	3.4	96	14.9	
GC 00138-10	3.4	97	12.5	
GC 00073-33	3.4	97	13.4	
GC 00139-79	3.3	96	12.8	
GC 00051-12	3.3	100	11.1	BP
GC 00042 46	3.3	95	13.4	
GC 00138 29	3.2	97	15.7	
G 8587 (Ck)	2.6	115	13.7	BP
AGS 181 (Ck)	1.9	91	18.0	
G 5422 (Ck)	1.6	101	28.4	
Mean of 100 entries	2.71	96	15.3	
CV (%)	10.73	1.88	3.82	
LSD (.01)	0.76	4.79	1.54	
(.05)	0.58	3.62	1.16	

[z]BP resistant to bacterial pustule

Preliminary and Intermediate Yield Trials, Autumn 1984

Introduction

Preliminary (PYT) and intermediate yield trials (IYT) in autumn were not included in the 1984 annual report since the experiments were not completed at that time.

Table 15. High-yielding genotypes in the preliminary yield trial-II (PYT-II), summer 1985.

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)	Remark[z]
AGS 129 (Ck)	4.7	96	17.0	BP
G 9947-21-9	4.2	94	18.3	BP
G 9947-19-6	3.9	95	17.7	BP
G 9947-12-13	3.9	95	18.2	BP
GC 40359-1-47-6-21-10	3.8	94	18.0	BP
GC 82200-7-12-19	3.2	95	15.7	
AGS 154 (Ck)	2.9	96	13.6	BP
AGS 181 (Ck)	1.7	83	19.1	
G 215 (Ck)	1.6	89	20.6	
Mean of 16 entries	3.01	93	17.78	
CV (%)	11.06	4.76	3.8	
LSD (.01)	0.98	13.09	1.99	
(.05)	0.71	9.46	1.44	

[z]BP resistant to bacterial pustule.

Table 16. High-yielding genotypes in the intermediate yield trial-I (IYT-I), summer 1985.

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)	Remark[z]
AGS 129 (Ck)	4.6	96	16.6	BP
GC 60058-12-6-6-1-39	3.6	92	14.5	
GC 60058-12-6-6-1-67	3.4	91	14.1	BP
GC 60058-12-6-6-1-37	3.3	91	14.1	BP
GC 60115-6-6-6-7-63	3.3	93	15.5	BP
GC 60058-12-6-6-1-18	3.2	91	13.3	
AGS 181 (Ck)	2.2	83	19.4	
Mean of 28 entries	2.65	88	15.45	
CV (%)	16.42	1.82	3.74	
LSD (.01)	1.21	4.46	1.6	
(.05)	0.89	3.30	1.19	

[z]BP resistant to bacterial pustule.

Materials and Methods

The PYT's and IYT's were conducted in three groups in autumn 1984. PYT-I, PYT-II, and PYT-III were planted on 14 September; IYT-I and IYTm7 (IYT of mutant 7) on 18 September; and IYT-II on 19 September 1985. A split plot design was used. The main plot consisted of treatments with and without fungicide; and the subplots were genotypes. Plot sizes for the PYT's and IYT's were 3 m x 1 m and 5 m x 2 m, respectively. The PYT's had two rows per plot while the IYT's had four rows; both trials had two replications each.

For the fungicide treatment, Dithane M-45 was sprayed on 30 October and 1 November 1984 in the IYT's and PYT's, respectively, when the rust symptom appeared. Thereafter, four additional sprays were given on 7, 13, 19, 28 November 1984 in both trials for fungicide treated plots. Standard AVRDC cultural practices were followed for PYT's and IYT's. Data for all the agronomic characters in both trials were collected and analyzed. Selected breeding lines from PYT were advanced to IYT (intermediate yield trial) and then to AYT (advanced yield trial). Selection was based on yield, resistance or tolerance to soybean diseases, days to maturity, and adaptability to more than one season.

Results and Discussion

The PYT's and IYT's of autumn 1984 were planted late, (mid-September 1984) because of rainy weather in the beginning of this month. The onset of cold weather began early in November 1984, thus resulting in stunted soybean plants in both trials.

The experimental fields of PYT's and IYT's in autumn were close to the summer soybean crop. As a result, rust from the latter seriously infected the former. Late planting, cold weather, a moist environment, and an abundant soybean rust inoculum all resulted in a very poor crop. Dithane M-45 was sprayed when the rust symptom was observed on 30 October 1984 (IYT I, IYTm7) and on 1 November 1984 (PYT); then additional sprays were given on November 7, 13, 19, and 28 for both trials on fungicide-treated plots. Unfortunately, the rust could not be contained by Dithane M-45 sprays.

In PYT I, 10 breeding lines and 1 accession yielded higher than the two check cultivars. In PYT-II, ten breeding lines had better yields than the check cultivars. In PYT III nine breeding lines outyielded the checks. Similarly, six breeding lines in IYT I (Table 17) and seven in IYT II had higher yields than the check cultivars.

The following entries performed better in yield than the checks in both fungicide and nonfungicide treatments: G 10146 and GC 60014-7-33-10 in PYT-I (Table 18); GC 60038-3-7-12-10-7-81 in PYT-II (Table 19); GC 60014-8-1-47-8, GC 60035-1-15-11, GC 60035-1-15-6, and GC 60035-1-15-8 in PYT-III (Table 20); and GC 60068-9-6 and GC 60068-9-9 in IYT-II (Table 21). In IYTm7, all the mutant lines matured 10 days earlier than the parental G 2120, but produced yields similar to G 2120. Yield loss due to rust was about 70% (Table 22). There were significant yield differences among genotypes in fungicide and nonfungicide treatments in PYT's and IYT's (Tables 17 to 22).

Table 17. High-yielding lines with and without fungicide treatment in the intermediate yield trial-I (IYT-I), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
GC 50106-11-79-9-6-6-8	0.7	84	7.8	0.2	82	6.0
GC 60066-107A-20-15-6-8	0.6	83	9.9	0.1	81	6.8
GC 60066-237B-7-10-6-7	0.6	84	10.6	0.2	80	6.1
GC 50136-5-6-6-9	0.5	81	9.0	0.2	81	7.1
GC 80028-1-6-1-7-1	0.5	82	13.2	0.1	81	11.3
GC 60066-107A-20-15-6-9	0.5	83	10.6	0.2	82	7.8
GC 60011-5-8-6-1	0.5	85	10.5	0.1	82	7.3
GC 50030-3-5-9-6-35	0.5	[illegible]	12.4	0.1	83	11.7
KS 8 (Ck)	0.4	80	15.5	0.2	84	14.6
IN 15 (Ck)	0.3	72	8.1	0.3	70	7.3
AGS 181 (Ck)	0.3	72	9.7	0.2	72	9.1
AGS 182 (Ck)	0.3	72	8.7	0.2	70	8.0
Shih Shih	0.3	77	10.2	0.1	77	9.4
Mean of 53 entries	0.35	81	10.6	0.14	80	9.2
CV (%)	20.31	2.1	6.7	20.31	2.1	6.7
LSD (.01)	0.13	4.5	1.7	0.13	4.5	1.7
(.05)	0.09	3.4	1.3	0.09	3.4	1.3

Conclusion

Many promising selections have been identified in the PYT's and IYT's for inclusion in the IYT's and AYT's, respectively.

Table 18. High-yielding lines with and without fungicide treatment in the preliminary yield trial-I (PYT-I), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
G 10146	3.2	94	13.7	1.1	89	9.1
GC 60014-7-33-10	2.4	88	14.8	1.2	86	11.1
G 10131	2.4	108	17.2	0.4	95	10.8
GC 60120-6-2-9-10	2.3	88	12.4	0.7	86	8.7
GC 60014-7-33-9	2.3	88	15.1	1.0	86	10.9
GC 60115-6-6-6-7-97	2.2	88	15.7	0.8	82	10.3
G 10316	2.2	94	12.7	0.6	89	10.0
G 38 (Ck)	1.1	80	13.3	0.8	77	10.1
G 42 (Ck)	0.5	78	19.0	0.6	76	16.3
Mean of 100 entries	1.15	85	13.6	0.67	81	9.9
CV (%)	21.26	2.12	6.85	21.26	2.12	6.85
LSD (.01)	0.61	4.6	2.1	0.61	4.6	2.1
(.05)	0.46	3.5	1.6	0.46	3.5	1.6

Table 19. High-yielding lines with and without fungicide treatment in the preliminary yield trial-II (PYT-II), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
GC 60038-3-7-12-10-7-81	1.6	88	13.1	1.0	88	11.2
GC 60115-8-6-11-8-36	1.6	90	15.2	0.3	88	12.6
GC 60115-6-6-9-8-29	1.6	91	15.1	0.5	87	10.3
GC 60115-6-6-6-7-42	1.6	89	14.6	0.7	86	11.1
GC 60115-8-6-11-8-60	1.6	90	15.1	0.4	88	12.4
GC 60038-3-7-12-10-7-89	1.6	88	13.5	0.6	88	10.3
GC 60049-5-6-6-8-7-55	1.6	90	13.1	0.5	87	10.3
GC 60038-3-7-12-20-7-28	1.6	88	13.7	0.5	86	10.2
GC 60058-12-6-6-1-49	1.5	85	12.1	0.6	84	9.4
GC 60115-6-6-6-7-34	1.5	90	15.4	0.6	87	11.4
G 38 (Ck)	0.9	81	12.9	0.6	80	10.7
G 42 (Ck)	0.5	81	18.3	0.6	77	16.3
Mean of 144 entries	1.11	87	14.0	0.54	85	11.2
CV (%)	30.47	1.88	6.1	30.47	1.88	6.1
LSD (.01)	0.65	4.23	2.0	0.65	4.23	2.0
(.05)	0.49	3.2	1.5	0.49	3.2	1.5

Table 20. High-yielding lines with and without fungicide treatment in the preliminary yield trial-III (PYT-III), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
GC 60014-8-1-47-8	1.8	87	13.0	0.7	82	9.1
GC 60035-1-15-11	1.6	86	13.8	0.7	82	10.6
GC 60011-5-2-32-10	1.5	86	13.3	0.6	84	10.9
GC 60035-1-15-6	1.4	85	14.0	0.8	82	11.2
GC 60014-7-15-9	1.4	89	12.7	0.5	83	9.4

Table 20. Continued.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
GC 60014-8-1-47-9	1.3	88	13.2	0.6	79	9.0
GC 60011-5-2-32-11	1.3	85	13.7	0.5	82	10.2
GC 60035-1-15-8	1.3	87	14.1	0.8	83	11.2
G 38 (Ck)	0.6	77	10.6	0.5	74	9.6
G 42 (Ck)	0.5	75	14.5	0.4	74	14.4
Mean of 90 entries	0.97	85	11.9	0.54	81	9.6
CV (%)	19.89	2.04	6.3	19.89	2.04	6.3
LSD (.01)	0.39	4.43	1.77	0.39	4.43	1.77
(.05)	0.30	3.35	1.34	0.30	3.35	1.34

Table 21. High-yielding lines with and without fungicide treatment in the intermediate yield trial-II (IYT-II), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
GC 60068-9-6	2.6	90	12.8	1.0	85	8.6
GC 60072-7-9-6-8	2.6	91	14.9	0.8	83	9.8
GC 60068-9-9	2.6	94	13.6	1.0	88	8.5
GC 60038-3-7-12-20-7	2.5	89	16.3	1.0	84	11.4
GC 60038-3-7-12-10-7	2.5	90	15.6	0.9	84	10.8
GC 60038-4-8-6-9	2.5	92	17.6	0.7	86	11.2
GC 80107-109[Y]	2.4	90	16.5	0.6	84	12.2
TN 15 (Ck)	1.8	82	15.2	0.9	78	9.8
Shih Shih (Ck)	1.6	83	14.6	0.6	79	9.8
AGS 182 (Ck)	1.6	80	16.3	0.5	77	10.6
G 10150 (Ck)	1.5	84	15.4	0.8	79	11.3
AGS 181 (Ck)	1.4	81	16.2	0.8	75	11.4
G 42 (Ck)	1.4	78	21.1	0.7	74	15.0
G 10210 (Ck)	1.0	80	10.0	0.4	73	4.9
Mean of 48 entries	2.05	87	15.8	0.71	83	11.0
CV (%)	12.71	1.48	5.46	12.71	1.48	5.46
LSD (.01)	0.46	3.3	1.92	0.46	3.3	1.92
(.05)	0.35	2.5	1.45	0.35	2.5	1.45

Table 22. High-yielding lines with and without fungicide treatment in the intermediate yield trial of mutant 7 (IYTm7), autumn 1984.

Cross Designation	With Fungicide			Without Fungicide		
	yield (t/ha)	days to maturity	100-seed wt (g)	yield (t/ha)	days to maturity	100-seed wt (g)
G 2120 (Ck)	1.3	91	5.5	0.4	83	3.4
37-1	0.9	81	4.9	0.3	76	3.3
79-5	0.9	81	5.0	0.3	77	3.5
110-3	0.8	82	4.8	0.3	77	3.6
20-4	0.8	82	4.9	0.3	77	3.3
81-2	0.8	80	5.3	0.4	78	3.7
G 42 (Ck)	0.3	76	14.5	0.1	70	13.2
Mean of 36 entries	0.77	80	5.3	0.29	77	3.6
CV (%)	11.53	1.25	6.21	11.53	1.25	6.21
LSD (.01)	0.16	2.6	0.73	0.16	2.6	0.73
(.05)	0.12	1.96	0.55	0.12	1.96	0.55

Achieving Maximum Soybean Yield in a Farmer's Field

Introduction

The objective of this study was to obtain maximum soybean yield in a farmer's field in the tropics. Factors limiting yield were identified and appropriately regulated. The positive interaction among high-yielding cultivars, farm inputs, and crop management was promoted to obtain maximum yield. A farmer cooperator was selected in Tung-Shih Township, about 90 km north of AVRDC. The field chosen for the experiment was well drained, fertile, and productive. Its previous crop was peanut.

Materials and Methods

The land was plowed and harrowed; then ridges and furrows were made by a tractor on 5 March 1985. The spacing between the center of one bed and the next was about 1 m; the width of each bed was about 50 cm. Two rows, 45 cm apart, were planted on each bed. Plot size was 5 m x 6 m with 12 rows/plot. In each hole spaced 10 cm apart, three to four seeds were sown manually on 6 March 1985.

On 6 March 1985, soon after land preparation but prior to planting, soil samples were taken at random by the soil scientists throughout the field and were analyzed in the laboratory to determine key soil characteristics. The following are the results of the soil analysis:

pH	8.00
Total nitrogen	0.112%
P_2O_5	54.27 ppm
K_2O	117.70 ppm
Ca	3,200.00 ppm
Mg	235.00 ppm
EC	0.20

The experimental design was factorial and consisted of:

1. Two varieties
   a. AGS 129, narrow-leaflet type
   b. AGS 66, broad-leaflet type
2. Three fertilizers

	N	P	K
a.	0	40	60
b.	20	80	120
c.	20	120	120

3. Two herbicides
   a. Lasso + Paraquat preemergence + hand weeding as necessary
   b. None [modified by the farmer's insistence to include treatment of 3(a) above]
4. Two insecticides
   a) As recommended
   b) None (control)
5. Two fungicides
   a) As recommended
   b) None (control)

Upon the farmer's request, herbicide treatments were used instead of as planned in 3(b) above and all plots were kept free of weeds. Therefore, factor 3 was eliminated. Soon after planting, the fertilizer mixture for each plot (already prepared) was uniformly distributed in a small furrow made

between the plant rows and covered. The seeds germinated uniformly on 15 March 1985. The experimental plots were visited and discussions were regularly held with the farmer once or twice a week, or more, whenever it proved necessary.

The seedlings were thinned to leave two plants per hill on 28 March 1985. Unfortunately, in most of the plots rabbits cut the meristems of many plants after thinning. An AVRDC crew immediately set up a nylon mesh cloth fence around the borders of the entire field to prevent further rabbit damage. The seedlings, however, suffered almost no mortality due to rabbit damage. The axillary buds below the point of damage took over the growth and the recovery was excellent.

The weather was cool after planting and as a result initial growth was slow; but when the temperature began to rise, rapid growth occurred (Fig. 5). Due to cloudy weather, plants grew quite tall. Despite fungicide treatment to control soybean rust well in advance of the appearance of the disease, the infection started and progressed steadily from the time of pod formation. When the plants were at R6.5 or 7.0 there was a heavy rain and severe lodging resulted. The fields were well drained, however.

The field was visited by Drs. Sanders and Hasegawa of The Potash and Phosphate Institute of Canada on 14 May 1985 when growth was very good.

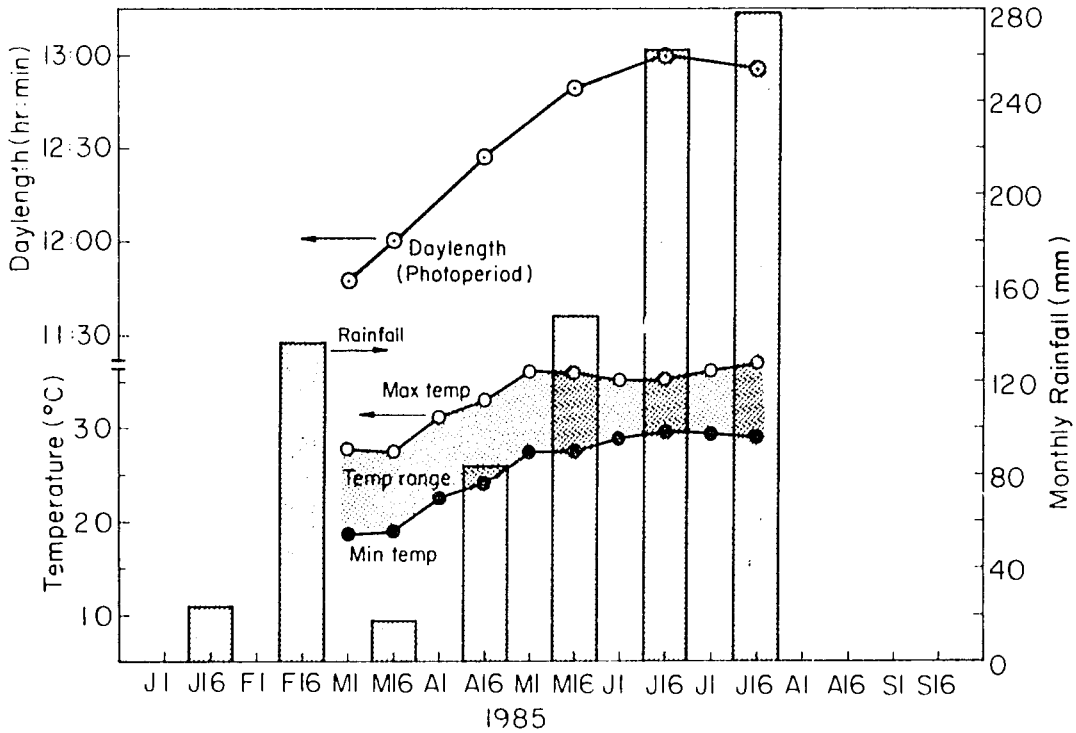

Fig. 5. Monthly rainfall, temperature, and day length in Tung-Shih from 1 January 1985 to 16 July 1985.

Results and Discussion

Statistically significant yield differences were observed between cultivars, fungicide treatments, and the interaction between cultivars and fungicides. AGS 66 yielded significantly higher than AGS 129 (Table 23). A 7.1% increase in yield obtained with fungicide application was significant (Table 24). AGS 129 had no response to fungicide application, but significantly increased the yield of AGS 66 by 14% (Fig. 6).

Previous studies have shown AGS 129 to have some level of tolerance to soybean rust. Rust infection was such that this cultivar was able to tolerate it without any yield reduction; consequently,

there was no significant difference in yield in fungicide-treated and untreated AGS 129 (Fig. 6). The data on soybean rust infection between the two cultivars support the above conclusion (Table 23). There was significantly lower rust infection in AGS 129 than in AGS 66 which had a significantly increased yield with fungicide application (Fig.6).

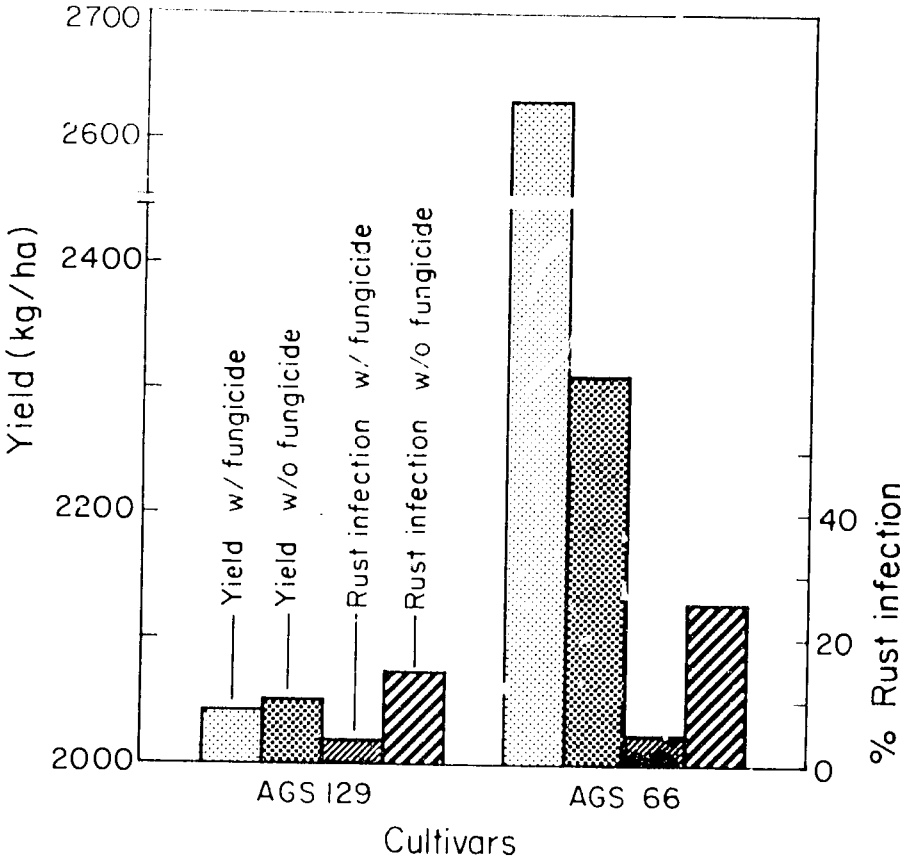

Fig. 6. Differences in yield and rust infection between fungicide and nonfungicide treatments in AGS 129 and AGS 66.

AGS 66 matured in 105 days and AGS 129, in 107 days (Table 23). Soybean rust disease hastened the maturity by two days (Table 24). The above differences were statistically significant. AGS 66 had a significantly smaller 100 seed weight than AGS 129 (Table 23). With fungicide treatment 100-seed weight increased by 8.3% over the unprotected plants (Table 24). Fungicide effectively reduced soybean rust infection from 20 to 4%.

The final soil test after harvesting the crop has not yet been completed.

Table 23. Differences between two cultivars on grain yield, maturity, 100-seed weight,and rust infection percentage.

Cultivar	Days to Maturity	100-Seed Weight (g)	Rust (%)	Yield (kg/ha)
AGS 66	105	10.75	15.35	2,468
AGS 129	107	14.40	9.23	2,047
LSD 5%	0.6	0.33	0.70	100
1%	0.8	0.44	0.93	132

Table 24. Grain yield, maturity, 100-seed weight, and rust infection percentage with and without fungicide treatments.

Treatment	Yield (kg/ha)	Days to Maturity	100-Seed Wt (g)	Rust Infection Percentage
With fungicide	2,335	107	13	4
Without fungicide	2,179	105	12	20
LSD 5%	100	0.6	0.33	0.70
1%	132	0.8	0.33	0.93

Conclusion

AGS 66 gave the highest yield of 2.6 t/ha in 105 days. A maximum yield of about 4 t/ha was expected, but unfavorable environmental conditions (cool temperature and cloud cover) and rabbit damage at the beginning of plant growth retarded the cultivar's initial vigor.

International Cooperation

Seed Distribution and Releases

To 116 cooperators in 38 countries, we distributed 46 sets of ASET seed packets, 343 breeding lines, and 303 accessions.

The major achievements in 1985 were the release to farmers of BPI-SY4 (AGS 73) in the Philippines, Kaohsiung Sel. 10 (AGS 129) by Kaohsiung DAIS in Taiwan for the summer season, and Kerinci (one parent of which is AVRDC's G 2120) in Indonesia.

AVRDC Soybean Evaluation Trials from Cooperators

Eleven AGS lines and accessions each were included in the 1984 and 1985 AVRDC soybean evaluation trials (ASET). The cultivars and their pedigrees are the following:

1984 ASET	Pedigree	1985 ASET	Pedigree
AGS 29	Clark 63 x 64-4	AGS 58	TN #4 x Yagi 1
AGS 58	TN #4 x Yagi 1	AGS 66	Forrest x Shih Shih
AGS 129	Shih Shih x SRF 400	AGS 129	Shih Shih x SRF 400
AGS 133	64-4 x 64-62	AGS 160	PI 227224 x 1039
AGS 146	PI 200492 x PI 227224	AGS 162	Clark 63 x 64-4
AGS 172	TN #4 x ORBA	AGS 200	PI 248407 x AGS #2
AGS 183	PI 194647 x PI 230971	AGS 209	Funmar x TN #3
AGS 204	KS 482 x Aochi	AGS 215	PI 248407 x Clark-63
AGS 208	KS 473 x Unknown	AGS 222	(AGS #2 x Shih Shih) x TN #4
AGS 217	Clark-63 x PI 248407	AGS 227	PI 248407 x Clark-63
AGS 228	KS 739 x Akiyoshi	G 2261	TN #15

The cooperators were requested to include one or two local cultivars as checks. Data received from 22 cooperators have been analyzed. Additional data are still being received.

Out of 16 trials presented in Table 25 from eight countries, AGS 58 and AGS 133 significantly outyielded the local checks in five trials. AGS 133 was also early maturing. AGS 129 was higher-yielding than the checks in four trials. As reported elsewhere in this report AGS 129 has already been released in Taiwan as Kaohsiung Selection No. 10.

The cropping system in which soybean is included in the cooperating countries are shown in Fig. 7. In Brazil and Zimbabwe corn-soybean is a common rotation; wheat-soybean is also common in Brazil. In all the Asian countries soybean is included in a cropping system either with rice or with other legumes, such as peanut or mungbean. In Zaire soybean is rotated with cassava.

Table 25. Results of AVRDC Soybean Evaluation Trial (ASET) from cooperators.

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity	SQ[y]	100-Seed Wt (g)	Remarks[x]
Brazil	AGS 29	2.1 a	94	3	15.1	P: 14 Feb. 1985
Lat. 24° 17'S	AGS 146	2.0 ab	90	3	18.0	T: 12
Alt. 300 m	AGS 133	2.0 ab	93	3	18.0	R: 4
Nelson S. Fonseca, Jr.	AGS 204	1.9 ab	90	3	17.0	
	AGS 58	1.9 ab	92	3	20.1	
	AGS 172	1.9 ab	95	3	16.8	
	AGS 129	1.8 abc	90	2	16.2	
	Local Ck	1.5 de	93	3	16.6	
Lat. 24° 56'S	AGS 129	2.7 ab	133	3	19.6	P: 10 Nov. 1984
Alt. 760 m	AGS 204	2.7 ab	134	3	19.3	T: 12
Nelson S. Fonseca, Jr.	AGS 208	2.5 abc	132	3	18.1	R: 4
	AGS 146	2.4 abcd	134	3	20.1	
	AGS 172	2.3 abcd	139	3	18.3	
	AGS 58	2.3 abcd	134	3	16.6	
	AGS 228	2.3 abcd	139	2	21.7	
	Local Ck	2.9 a	128	2	15.9	
Burma	AGS 58	1.0	75	2	13.6	P: 29 Nov. 1984
Lat. 19° 51'N	AGS 133	1.3	74	4	11.9	T: 13
R. K. Palis	Local Ck	0.8	70	2	12.4	R: 4
	Local Ck2	0.7	66	3	13.5	
	LSD (.05)	NS				
Lat. 19° 10'N	AGS 208	2.1 a	79	2	19.6	P: 30 Nov. 1984
Alt. 97.6 m	Local Ck	1.4 b	72	1	8.8	T: 10
Daw Thim Thim Nwe						R: 4
Colombia	AGS 217	3.1 a	87	2	16.9	P: 24 Oct. 1984
Lat. 3° 44'N	AGS 129	3.1 a	91	3	17.9	T: 11
Alt. 400 m	AGS 58	2.9 a	86	2	20.8	R: 4
Lvis Melendrez C.	AGS 172	2.9 a	84	3	18.1	
	AGS 204	2.8 ab	82	2	19.5	
	AGS 208	2.8 ab	79	2	24.0	
	AGS 133	2.7 abc	81	2	18.8	
	AGS 146	2.7 abc	83	2	20.3	
	AGS 29	2.7 abc	90	2	17.2	
Indonesia	AGS 58	1.9 a				P: 8 Sept. 1984
Lat. 0° 11'S	AGS 228	1.9 ab				T: 14
Alt. 10 m	AGS 208	1.8 abc				R: 4
Ch. Lorenz	AGS 146	1.6 abcd				
	AGS 217	1.5 abcde				
	AGS 129	1.5 abcde				
	Lokan	1.4 bcde				
	ORBA	1.3 de				
	Galunggung	0.7 f				
Indonesia	AGS 133	1.9	83	2	13	P: 15 Aug. 1984
Lat. 8° 9'S	MLG2599 (Ck1)	2.2	93	2	10	T: 14
Alt. 335 m	MLG2521 (Ck2)	1.9	100	3	7	R: 4
J. S. Siemonsma	MLG2542 (Ck3)	1.7	97	3	8	
	LSD (.05)	0.2				
Lat. 11° S	AGS 146	1.2 a	85	2	17.1	P: 15 Jan. 1985
Alt. 150 m	AGS 204	1.1 ab	85	2	16.0	T: 12

Table 25. Continued.

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity	SQ[y]	100-Seed Wt (g)	Remarks[x]
Siemon Field	AGS 217	1.1 ab	85	1	14.5	R: 4
	AGS 133	1.0 ab	85	4	15.6	
	AGS 183	1.0 ab	85	2	12.5	
	AGS 228	0.8 abc	85	2	18.2	
	Local Ck	0.4 cd	86	2	11.9	
	Local Ck	0.2 d	85	1	12.4	
Pakistan	AGS 129	2.2 ab				P: 27 July 1984
Lat. 34° 47'	AGS 208	2.2 ab				T: 12
Alt. 4000 ft	Local Ck	2.4 a				R: 4
Ismail Khan						
Philippines	AGS 208	1.0	93		20	P: 29 May 1984
Lat. 16° 42.3'N	AGS 58	0.8	98		21	T: 11
Alt. 66 m	AGS 29	0.8	98		20	R: 4
Andres C. Pascua	AGS 133	0.8	98		18	
	BPI SY2 (Ck)	0.7	98		18	
	LSD (.05)	NS				
Lat. 16° 12.3'N	AGS 58	2.5			22.0	P: 6 June 1985
Alt. 66 m	AGS 129	2.4			17.9	T: 12
Andres C. Pascua	AGS 209	2.1			20.9	R: 4
	AGS 162	2.1			19.2	
	AGS 222	2.0			14.6	
	AGS 66	1.9			14.6	
	AGS 160	1.7			14.2	
	AGS 215	1.6			16.5	
	Local Ck	1.6			15.9	
	LSD (.05)	0.9				
Lat. 16° 47'N	AGS 217	1.9 a	109	2	14.6	P:27 Mar. 1985
Alt. 1200 m						T: 10
Crispulo S. Tandoc						R: 4
Lat. 7° 54'N	AGS 58	2.0 a		2	16.2	P: 4 June 1985
Rico Jampos	AGS 162	1.8 ab		2	13.8	T: 12
	AGS 209	1.7 bc		2	15.3	R: 4
	AGS 222	1.7 bc		2	12.0	
	AGS 227	1.7 bc		1	13.4	
	AGS 215	1.6 bcd		2	13.5	
	AGS 129	1.5 bcd		2	12.7	
	Local Ck	1.2 e		4	7.9	
Thailand	AGS 228	1.5 a	89	1	19.1	P: 15 Jan. 1985
Lat. 18° 55'N	AGS 183	1.5 a	92	2	11.5	T: 12
Alt. 316.53 m	AGS 217	1.4 ab	94	2	20.2	R: 4
Thongchai Tonguthaisri	Local Ck1	1.3 bc	101	2	19.1	
	Local Ck2	1.1 cd	99	1	18.7	
Lat. 17° N	AGS 65	1.7 a		1		P: 19 July 1984
Alt. 150 m	AGS 79	1.6 ab		2		T: 11
Sanit Luadthong	AGS 124	1.4 abc		1		R: 4
	AGS 19	1.3 abcd		3		
	Local Ck1	1.0 bcde		2		
	Local Ck2	0.5 e		2		

Table 25. Continued.

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity	SQ[y]	100-Seed Wt (g)	Remarks[x]
Zimbabwe	AGS 58	2.9 b	118	3	20.3	T: 12
Lat. 17° 40'S	AGS 208	2.7 bc	112	2	20.5	R: 4
Alt. 1300 m	Duiker (Ck)	4.0 a	119	2	21.5	
J. R. Tattersfield						

[z]NS = not significant. [y]SQ = Seed quality. [x]P = planting date; T = total number of entries; R = replication.

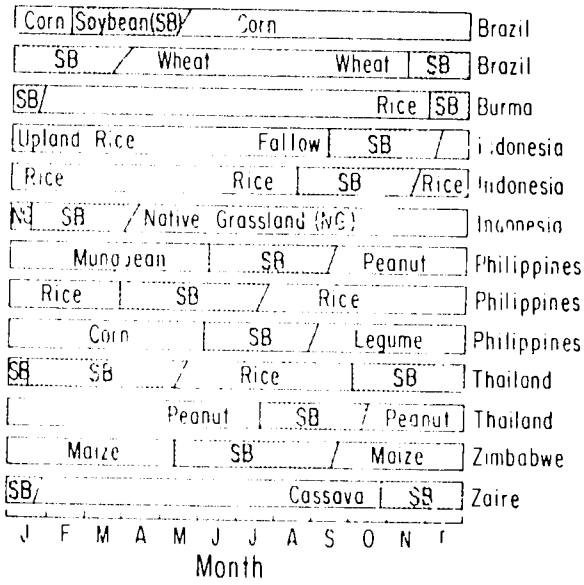

Fig. 7.
Cropping systems with soybean in countries conducting AVRDC soybean evaluation trials in 1983-85.

AVRDC-Mission China Cooperation

In cooperation with Mission China, AVRDC provided 130 AGS lines for evaluation at Liberia, Guanacaste, Costa Rica by Mr. T. S. Toung. The experiment was planted on 22 August 1984 in a 1.2 m x 5 m plot with two replications.

There was no significant difference in yield between AGS lines and the check cultivar; however, nine AGS lines matured earlier (Table 26). The yield of AGS lines ranged from 1.0 to 1.5 t/ha (Fig. 8) and days to maturity ranged from 86 to 90 days from sowing (Fig. 9).

AVRDC-OPRSC Cooperation

AVRDC provided 290 AGS lines and 23 accessions for evaluation by Dr. T. E. M. Odendaal at the Oil and Protein Research Seed Center (OPRSC) at Buffelspoort, South Africa. The experiment was planted on 20 November 1984, in 4 m^2 nonreplicated plots. Rainfall was 493 mm during the trial at Buffelspoort

Twenty-five AGS lines whose yields exceeded that of the check cultivar are given in Table 27. Most of the AGS lines yielded below 2.5 t/ha. About 58% of the AGS lines matured between 141 to 150 days after sowing. Four AGS lines gave more than 4 t/ha. Among them AGS 275 was found to be nonlodging, nonshattering, and with good seed quality.

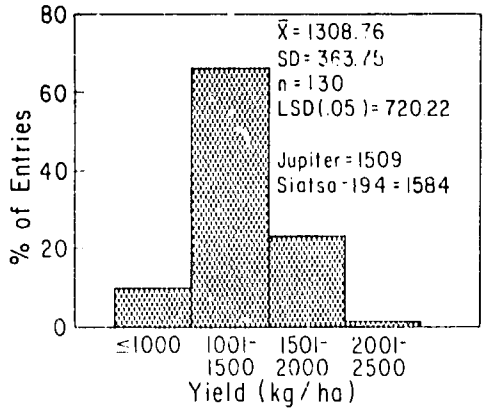

Fig. 8. Frequency distribution of yield of AGS lines planted in Costa Rica.

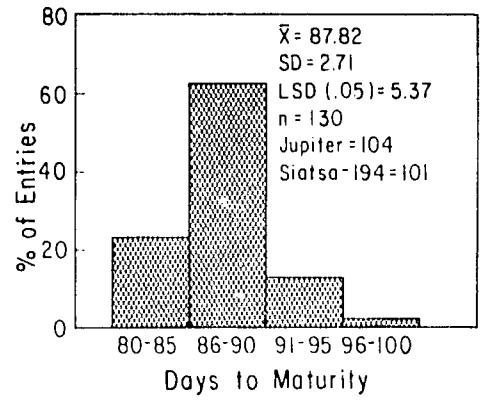

Fig. 9. Frequency distribution of days to maturity of AGS lines planted in Costa Rica, 1984.

Table 26. Nine early-maturing and high-yielding AGS lines selected from 130 AGS lines planted at Liberia, Guanacaste, Costa Rica, 1984.[z]

AGS No.	Yield (t/ha)	Days to Maturity	Harvested Stand/6 m^2
AGS 46	1.3	84	215
AGS 25	1.7	84	234
AGS 45	1.4	85	207
AGS 53	1.4	85	246
AGS 44	1.4	85	245
AGS 57	1.4	85	210
AGS 168	1.6	85	236
AGS 50	1.8	85	237
AGS 36	1.5	85	198
Jupiter (Ck1)	1.5	104	261
Siatsa-194 (Ck2)	1.6	101	228
LSD (.05)	NS[y]	5.37	70.46

[z]Date planted: 22 Aug. 1984; plot size: 6 m^2 (1.2 m x 5 m); location: University of Costa Rica, Liberia, Guanacaste; total entries: 130; replication: 2; cooperator: T. S. Toung. [y]NS = not significant.

AVRDC-CRIFC Cooperation

We sent 34 mutant lines (mutant of G 2120) to Dr. Sumarno at the Central Research Institute for Food Crops (CRIFC), Bogor, Indonesia. They were planted on 8 October 1984. Plot size was 5 x 1 m^2 with two replications. Observations were recorded for six agronomic characters, including yield, and for soybean rust incidence. Except for line 20-4, there were no significant differences in yield between 33 mutant lines and high-yielding check cultivars B-3035, G 2120, and Wilis (Table 28). The yield per hectare per day of the high-yielding mutants was about 0.01 t, while that of the checks (G 2120, B-3035, and Wilis) ranged from 0.007 to 0.008 t/ha each day. The early-maturing local checks gave only 0.004 and 0.005 t/ha each day.

The high-yielding mutants matured 18 days earlier than the parent, G 2120, and 12 days earlier than the check cultivars B-3035 and Wilis. Therefore, the G 2120 mutants appear to be promising in Indonesia as cultivars for specific cropping systems which require early maturity.

Table 27. Twenty-five high-yielding lines from 290 AGS lines for evaluation in South Africa, 1984.[z]

Cultivar	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)	Lodging	Shattering	Seed Quality
AGS 160	4.7	146	18.6	5	–	4
AGS 170	4.6	157	10.3	4	5	2
AGS 275	4.1	154	16.7	1	1	2
AGS 123	4.0	141	16.5	4	3	3
AGS 180	4.0	157	14.3	4	5	4
AGS 50	3.8	154	15.5	2	2	4
AGS 61	3.8	154	15.5	2	2	4
AGS 278	3.7	128	12.8	4	3	3
AGS 161	3.6	153	15.6	2	3	2
AGS 129	3.6	141	17.6	4	4	2
AGS 71	3.6	141	16.2	3	4	3
AGS 204	3.6	122	16.0	5	3	2
AGS 164	3.6	142	19.1	1	1	2
AGS 200	3.5	113	12.4	3	2	1
AGS 19	3.5	147	16.0	3	1	3
AGS 162	3.5	154	15.7	3	3	3
AGS 128	3.5	121	14.7	1	2	3
AGS 246	3.5	146	15.0	4	3	3
AGS 68	3.4	141	21.2	4	4	2
AGS 261	3.4	142	16.6	4	4	3
AGS 11	3.4	147	14.9	1	1	3
AGS 83	3.4	147	17.3	4	3	3
AGS 266	3.4	154	13.0	3	4	2
AGS 138	3.3	113	15.6	1	1	3
AGS 215	3.3	142	15.7	4	4	2
Check Variety	3.2	133	14 9	11	1	2
Mean	1.8	141				
SD	0.89	13.61				

[z]Date planted: 20 Nov. 1984; date harvested: 3 March 1985; location: Buffelspoort; plot size: 1 m x 4 m with 1 replication; cooperator: T E.M. Odendaal.

AVRDC-UPLB and PSU Cooperation

AVRDC provided 103 F7 generation lines and 7 breeding lines for evaluation at the University of the Philippines at Los Baños (UPLB) and Pangasinan State University (PSU) by Mr. Rudy S. Navarro. The 103 lines were planted on 14 December 1984 and 4 December 1984 at UPLB and PSU, respectively. The plot size was 1 m x 0.5 m with no replication. Seven breeding lines were included in the general yield trials arranged in a randomized complete block design with three replications and each plot size of 5 m x 2 m. This yield trial was planted at UPLB and PSU on 10 December 1984 and 26 November 1984, respectively.

At UPLB, 61% of AVRDC F7 lines had a yield range between 1.0 to 2.0 t/ha while 80% of TGX lines had below 1.0 t/ha (Fig. 10). At PSU, 42% of AVRDC F7 lines and 16% of TGX lines had a yield range between 0.1 to 0.25 t/ha; 19% of AVRDC F7 lines had a yield range between 0.25 to 0.4 t/ha; but 84% of the TGX lines produced less than 0.1 t/ha (Fig. 11).

The AVRDC breeding lines showed high yield at UPLB (1.6 to 2.7 t/ha), but the yield range at PSU was only 0.2 to 0.4 t/ha (Table 29). Higher yield at UPLB was due to sufficient moisture for the soybean crop. The poor yield at PSU was due to lack of moisture and drought.

Table 28. Major agronomic data of the mutant M_7 of G 2120 planted at Bogor, Indonesia, 1984.[z]

No. of G 2120 M_7	Yield (t/ha)	Days to Maturity	Lodging	Rust Rating[y]	No. of G 2120 M_7	Yield (t/ha)	Days to Maturity	Lodging	Rust Rating[y]
54-1-2	0.8	81	2	S	1-2	0.6	82	2	S
41-3	0.8	81	2	S	24-2	0.6	81	2	S
18-5	0.7	81	3	S	96-2	0.6	81	3	S
61-1-3	0.7	82	2	S	26-4	0.6	81	3	S
21-5	0.7	81	2	S	31-4	0.6	81	3	S
69-4	0.7	81	2	S	17-4	0.6	81	2	S
79-5	0.7	81	3	S	57-1-5	0.6	81	2	S
68-1	0.7	81	2	S	110-3	0.6	82	3	S
10-1	0.7	81	2	S	86-2	0.6	81	3	S
39-5	0.7	81	2	S	37-1	0.6	81	2	S
117-1	0.7	81	3	S	35-5	0.6	81	2	S
64-3	0.7	82	3	S	11-3	0.6	81	2	S
151-2	0.7	81	2	S	28-5	0.5	81	3	S
69-1	0.7	81	2	S	20-4	0.3	81	3	S
84-4	0.7	81	1	S	B-3035 (Ck)	0.7	93	2	R
50-5	0.7	81	3	S	AGS 2 (Ck)	0.7	99	2	S
82-4	0.6	82	3	S	Wilis (Ck)	0.7	93	2	T
73-1	0.6	81	2	S	Lokon (Ck)	0.4	82	2	S
34-1	0.6	81	2	S	Orba (Ck)	0.3	82	2	S
52-3	0.6	81	2	S	G 42 (Ck)	0.1	79	3	S
Grand mean	0.61	82.1	2.05						
SD	0.11	0.38	0.72						
CV (%)	17.83	0.47	35.11						
LSD (0.5)	0.22	0.78	1.46						

[z]Date planted: 8 Oct. 1984; plot size: 4 x 5 m², replications: 2; total entries: 40. [y]Rust rating: S = susceptible, T = tolerant, R = resistant.

Table 29. Yield and days to maturity of AVRDC breeding lines planted after rice, 1984-1985, UPLB and PSU, Philippines

Cross Designation	UPLB		PSU	
	yield (t/ha)	days to maturity	yield (t/ha)	days to maturity
GC 60068-9	2.7	82	0.3	97
GC 50193-7-6	2.6	80	0.3	97
GC 50128-6-6	2.3	82	0.4	97
GC 50123-8-6	2.3	83	0.4	97
GC 60030-4	2.0	80	0.3	81
GC 30187-10-15	1.6	80	0.2	88
GC 50188-7-8	n.d.[z]	90	0.2	81
LSD (0.5)	1.29	–	0.11	–

[z]Data not available.

Other Trials

The results of other evaluations of our breeding lines and accessions by cooperators are shown in Table 30. Among the breeding lines evaluated, AGS 29, 58, 66, 129, and G 2120M_7 appear to be promising in selected countries. Many of these will be further evaluated by the cooperators in these countries for either possible release as new cultivars or use in their breeding programs.

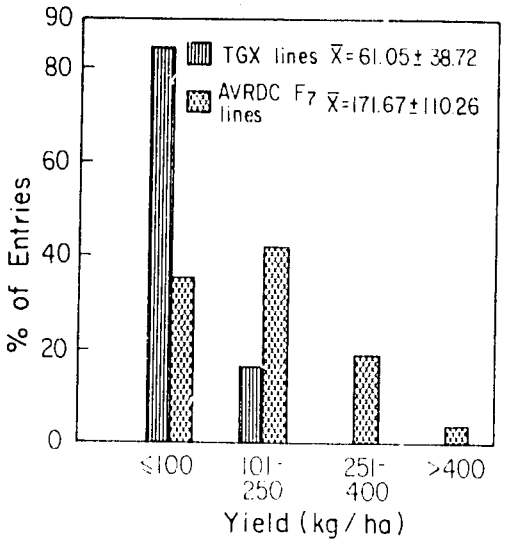

Fig. 10. Frequency distribution of yield of AVRDC F7 and TGX lines planted at UPLB, Philippines, 1984-85.

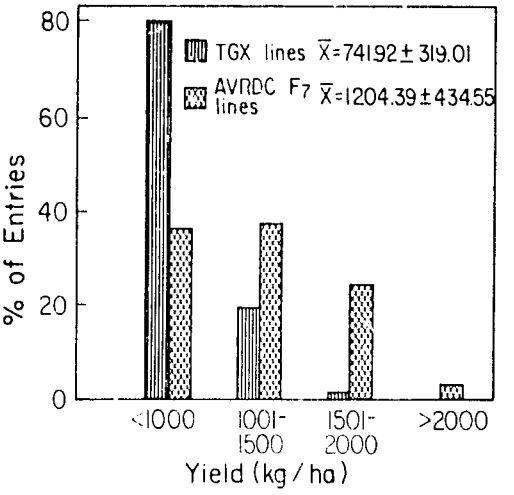

Fig. 11. Frequency distribution of yield of AVRDC and TGX lines planted at PSU, Philippines, 1984-85.

Table 30. Summarized results of other international cooperative trials.

Country Location Cooperator	Variety or Name	Yield[z] (t/ha)	Days to Maturity	SQ[y]	100-Seed Wt (g)	Remarks[x]
Belize Belmopan B. K. Rai	AGS 58	3.0 a	100	2	30	P: 19 Nov. 1983
	AGS 129	2.7 a	100	2	21	T: 8
	AGS 29	2.7 a	100	2	22	
	AGS 12	2.6 ab	93	1	24	
	AGS 130	2.6 ab	93	2	29	
Burma Thitcho E. T. Bullard	AGS 3	2.0				P: Nov. 1984 T: 8
Costa Rica Liberia, Guanacaste T. S. Toung	G 2514	4.2	96			P: 6 Aug. 1984
	G 10337	3.2	97			T: 76
	G 10438	3.1	87			R: 1
	G 2509	3.0	95			
	G 2037	2.8	84			
Liberia, Guanacaste T. S. Toung	AGS 17	1.4 abc	87	1		P: 14 Aug. 1984
	AGS 144	1.4 abc	87	1		T: 30
	AGS 129	1.2 abcde	91	2		R: 2
Liberia, Guanacaste T. S. Toung	AGS 19	2.8 bcd	88	2		P: 29 Aug. 1984
	AGS 124	2.6 cde	95	2		T: 16
	AGS 8	2.4 de	90	1		R: 4
	AGS 143	2.2 e	90	1		
Indonesia Sawah field Donald R. Schmidt	G 2120 M$_7$	1.3	81			P: 3 July 1985
	Local Ck	1.1	81			T: 8
	LSD (.05)	0.4				R: 2

Table 30. Continued.

Country Location Cooperator	Variety or Name	Yield[z] (t/ha)	Days to SQ[y] Maturity		100-Seed Wt (g)	Remarks[x]
Bandungan	AGS 129	3.2	101		17.8	P: 4 Jan. 1985
W. H. Wang	AGS 66	2.7	92		14.7	T: 6
	G 2120 M.	2.4	104		7.4	R: 2
	GC 60062-8-7-6	2.4	98		13.2	
	Local Ck	1.9	96		12.6	
BPP Karangpandan	AGS 66	3.5	75		13.5	P: 23 Feb. 1985
W. H. Wang	G 2120 M	3.4	80		6.5	T: 6
	Local Ck	3.4	81		10.0	R: 2
Kadipaten	AGS 210	1.2	78			P: 23 Oct. 1984
Donald R. Schmidt	Local Ck	0.6	78			T: 18
	LSD (.05)	0.5				R: 2
Pamalayan	G 2120	2.1				P: 27 Oct.1984
Donald R. Schmidt	Local Ck	1.8				T: 15
Surusunda	AGS 103	2.9				P: 28 Nov.1984
Donald R. Schmidt	AGS 148	2.0				T: 10
Local Ck	2.0					R: 1
Malaysia	AGS 58	2.1 a	95	3	25.4	P: 26 July 1984
Tuaran, Sabah	AGS 29	2.0 ab	95	3	20.5	T: 12
Liaw Hiew Lian	AGS 129	2.0 ab	95	3	20.1	R: 4
	AGS 17	1.9 ab	91	2	19.0	
	AGS 130	1.8 abc	91	4	25.9	
	Local Ck	1.7 bc	102	2	16.2	
Panama	AGS 58	2.1	86		23	T: 2
Rio Hato	AGS 29	2.1	88		18	
Gaspar Silvera						
Philippines	AGS 85	1.6	91	1	11.8	P: Dec. 1984
Los Baños	AGS 19	1.6	88	1	11.9	T: 9
B. V. Legaspi	AGS 12	1.2	89	1	11.6	R: 4
T. D. Gajete	AGS 17	1.6	90	1	11.9	
	G 2261	1.6	90	1	11.7	
	Local Ck	1.7	88	1	12.5	
	LSD (.05)	NS				
Calauan	AGS 211	3.3	84	2	18.5	P: 22 Jan.1985
B. M. Legaspi	AGS 227	3.2	84	2	18.8	T: 16
	AGS 225	2.9	84	2	23.8	R: 3
	Local Ck	2.1	84	2	19.8	
	LSD (.05)	0.8				
Philippines	AGS 11	1.3	74	2	13.5	P: 12 Dec. 1984
Isabela	AGS 5	1.2	74	1	15.0	T: 20
R. L. Raymundo	AGS 2	1.1	88	1	5.5	R: 1
Bohol	AGS 188	1.6	102	3	38.5	P: 17 May 1984
M. Yasuo	G 8285	0.9	110	3	35.6	T: 6
	AGS 187	0.8	103	3	30.0	R: 2
	Local Ck	1.4	116	2	20.2	
	LSD (.05)	0.9				

Table 30. Continued.

Country Location Cooperator	Variety or Name	Yield[z] (t/ha)	Days to Maturity	SQ[y]	100-Seed Wt (g)	Remarks[x]
Sri Lanka	GC 50228 2-7-6-6	3.0	79		15.9	P: 24 April 1984
Maha Illuppallama	GC 50228-1-38-6	2.9	83		21.0	T: 24
V. Arulnandhy	Local Ck	4.0	91		14.0	
	LSD (.05)	NS				
St. Lucia	AGS 187	6.5 a				P: 21 Dec.1984
La Ressource	AGS 190	6.0 ab				T: 8
A. Sajjapongse	AGS 191	5.2 abc				Yield data were
	AGS 185	4.7 abc				collected on
	G 9053 (Ck)	3.7 c				fresh pods.
	G 10134 (Ck)	6.5 a				
U.S.A.	AGS 129	4.7	143	3	21.2	P: 11 May 1984
Tifton, Georgia	AGS 154	3.6	126	3	15.0	T: 5
Myron B. Parker	AGS 62	2.8	125	3	18.4	
	AGS 188	2.1	132	4	41.1	
	AGS 186	1.0	129	3	29.5	

[z]NS = not significant. [y]SQ = seed quality. [x]P = planting date; T = total number of entries; R = replication.

Soybean Entomology

Screening of Selected Soybean Accessions for Tolerance to Beanflies

Introduction

Three species of agromyzid flies (commonly called beanflies) are economically important pests of soybean in tropical to subtropical Asia. These species - *Ophiomyia phaseoli*, *O. centrosematis*, and *Melanagromyza sojae* (Diptera: Agromyzidae) have a wide host range among the legumes. Since the larvae feed concealed inside the stem, its damage goes unnoticed. Until now only a few wild soybean (*Glycine soja*), accessions have shown resistance to these pests. The resistant accessions possess very thin stems, an agronomic character which is distinctly undesirable.

Since 1981 we have been screening our germplasm for tolerance to beanflies. A tolerant cultivar suffers no yield reduction despite heavy beanfly infestation. In 1984-85 we screened 182 accessions in a preliminary nonreplicated test and 16 additional accessions and breeding lines in a second replicated test, for tolerance to beanflies, mainly *M. sojae*.

Materials and Methods

A 1-ha field was rototilled, applied with basal fertilizers, and worked into 1-m-wide beds. These beds were further divided into two adjacent 5-m-long plots for the preliminary test and into 8-m-long plots for the second. A 0.25-m distance was maintained between two adjacent beds. Seeds of each entry were planted in two parallel rows 40 cm apart on two adjacent plots separated by a 0.25-m empty space. A distance of 10 cm was maintained between two adjacent hills in each row.

For the preliminary test, seeds of each entry were planted in only one plot; whereas for the secondary test, seeds were planted in three randomly selected plots each representing one replicate. The crop was raised according to customary cultural practices (including insecticide application), except one of the two adjacent plots which was left untreated as control. Two insecticides, monocrotophos and omethoate, were alternately sprayed at the rate of 0.5 kg a.i./ha at 3, 7, 10, 17, 24, and 31 days after germination.

Four weeks after germination, the crop was sampled by uprooting 10 plants from each of the two adjacent plots of each entry. The stems of each plant were cut open and the number of beanfly-damaged and healthy plants were recorded. At this time thinning was done to maintain an approximately equal number of plants in each adjacent plot of each entry.

Starting six weeks after planting we sprayed the entire field with contact insecticides, such as deltamethrin or fenvalerate, to protect the plants against other mostly polyphagous insect pests. At harvest we recorded the seed yield per plot.

Results and Discussion

In the preliminary screening, beanfly damage in the control plots with no insecticide spray ranged from 70 to 100% of the plants; in the insecticide-treated plots, it ranged from 0 to 45%. Yield loss varied from 0 to 63%. The entries with yield loss of 5% or less are listed in Table 1. Only one entry in this category was an AVRDC breeding line; the other six entries were accessions. In past tests

less yield loss was observed in breeding lines than in accessions; no such trend was evident in the 1984-85 trials. Nonetheless, the seven entries that had yield reduction of 5% or less appeared to be promising.

Since the sole criterion for beanfly tolerance was yield which is influenced by many factors, these entries will be tested once more in autumn 1986 in a multireplicate test with a large plot size.

In the secondary screening, 14 accessions and breeding lines that showed high levels of beanfly tolerance in the 1983-84 tests were included in this 1985 test. The data on beanfly infestation and yield reduction of these entries are summarized in Table 2. In insecticide-protected plots, plant damage ranged from 2 to 25%, while in control plots it ranged from 93 to 100%. Yield reduction was from 7 to 40%, a range considerably higher than that of the entries tested in the single-replicate test in 1983-84. Nonetheless, four entries showed less than 10% yield reduction and are now being evaluated for stability under various environmental and beanfly population levels.

Table 1. Performance of selected soybean germplasm in a preliminary screening for tolerance to beanflies.

Entry No.	Plant Damage (%)		Yield (kg/plot)		Yield
	+ insecticide	check	+ insecticide	check	Loss[z] (%)
G 1309	5	100	0.65	0.64	2
G 1501	5	95	1.00	1.73	0
G 2124	10	100	0.62	0.59	5
G 2264	0	95	0.38	0.36	5
G 2320	15	100	1.20	1.15	4
G 2468	5	70	0.75	0.75	0
PP 8[y]	45	100	1.07	1.49	0
PP 5[x]	15	100	1.13	0.49	57
G 1724	15	100	1.12	0.52	54

[z]Average yield loss for 182 entries 33.36%. [y]PP 8 60087 7-9 6 12 8.
[x]PP 5 C-56 1 BK Bke BKI II BK

Table 2. Performance of selected soybean germplasm in a secondary screening test for tolerance to beanflies.

Entry No.	Plant Damage (%)		Yield (kg/plot)		Yield
	+ insecticide	check	+ insecticide	check	Loss[z] (%)
G 342	17	95	1.16	0.69	40.00 a
G 3517	10	100	0.50	0.47	9.00 bc
G 531	7	98	0.82	0.60	28.33 ab
G 8586	10	93	0.63	0.57	8.33 bc
G 553	13	100	0.49	0.44	10.00 bc
A 32	25	100	0.57	0.53	9.00 bc
G 1992	17	100	0.59	0.49	16.90 bc
C 21	10	100	0.81	0.78	7.33 c
G 5422	11	100	0.93	0.68	27.00 abc
AGS 183	8	95	1.08	0.77	28.00 ab
[illegible] 3	2	100	0.79	0.65	16.67 bc
[illegible] 42	15	100	0.79	0.67	16.67 bc
AGS 229	7	98	1.00	0.89	11.33 bc
G 6	8	100	0.36	0.32	11.00 bc

[z]Average yield loss for 14 entries 17.50%.

Conclusion

Seven entries out of 182 in the unreplicated preliminary test showed yield reduction of 5% or less. Four entries out of 14 in the three-replicate, secondary test had reduction of less than 10%. These entries will be evaluated in 1985-86 for stability under various levels of beanfly population.

Insecticide Screening for Beanfly Control in Soybean

Introduction

In tropical and subtropical areas, soybean is infested by numerous insect pests, including beanflies which reduce plant vigor and in some locations kill the plants. At the moment insecticides are the most effective and practical control method. However, because of increasing prices of agricultural chemicals, their adverse effects on the environment, and the possibility of producing insecticide-resistant insect strains, insecticides should be used judiciously. At AVRDC, an ongoing program screens and selects insecticides that are effective and economical. In 1984-85 one such test was conducted and the results are described in this report.

Materials and Methods

A parcel of land was rototilled and worked into 1-m-wide raised beds. The beds were further divided into 3.3 m x 3 m plots. Seeds of cultivar KS 9 were sown in two parallel rows set 40 cm apart on each bed and at a distance of 10 cm between hills at the rate of four to five seeds per hill in each plot. Fertilizer application, weeding, thinning, irrigation, and other necessary cultural practices were followed.

There were 10 treatments including a control, replicated four times and arranged in a randomized complete block design. Predetermined quantities of insecticide formulations were diluted in water and sprayed on each plot with a 10-liter air-pressure sprayer charged to 2.7 kg/cm^2 (40 psi). A 0.5-liter spray volume (50% of the designated quantity of the active ingredient) was applied per plot during the first four applications and 1 liter per plot (1,000 liters/ha) at the succeeding three applications.

Each sprayer was individually calibrated with a stopwatch, and specific volumes of spray solution could be accurately and uniformly delivered to each plot to ensure that a specified amount of active ingredient was applied. Sprayings were done at 3, 7, 10, 14, 21, 28, and 35 days after emergence (DAE).

Insecticide effectiveness was evaluated at 21 and 35 DAE. Thirty plants at random were uprooted from each plot. Each plant was cut open and the number of larvae and pupae found within the stems were recorded. Likewise, the number of plants with visible beanfly damage, but without larvae or pupae, was also recorded.

Starting 35 DAE, the entire experiment was protected against other pests by occasional sprays of fenvalerate. At harvest, seed yield from each plot was recorded. All data were analyzed by Duncan's multiple range test.

Results and Discussion

The results of the insecticide screening are summarized in Table 3. Five synthetic pyrethroids and one avermectin compound were included in this trial, along with three organophosphorus insecticides which, in the past, have consistently given satisfactory control of beanflies. None of the synthetic pyrethroids gave adequate control of the beanflies. Monocrotophos and omethoate performed well, but did not result in increased yield. There was no statistically significant difference in yield due to any insecticide treatment.

Conclusion

In one insecticide screening test wherein synthetic pyrethroids were tested, along with standard organophosphorus compounds, none of the pyrethroids gave as good a control of beanflies as omethoate or monocrotophos, the standard insecticides.

Table 3. Evaluation of insecticides for the control of beanflies on soybean.[z]

Insecticides	Rate (kg a.i./ha)	No.Beanfly Maggots + Pupae/30 Plants		Damaged Plants (%)		Yield (t/ha)
		10-30-84	11-13-84	10-30-84	11-13-84	
Deltamethrin 2.8EC	0.05	26.75 ab	28.00 c	83.50 b	92.25 ab	1 060
Sumicidin 20EC	0.10	31.75 ab	31.75 c	94.25 a	96.75 a	.905
Cypermethrin 5EC	0.10	31.00 ab	35.75 ab	96.00 a	100.00 a	1.130
Permethrin 10EC	0.10	34.00 a	40.00 a	100.00 a	100.00 a	1.065
Baythroid 50EC	0.10	32.75 ab	36.25 ab	92.50 ab	96.75 a	1.030
MK 936 0.36EC	0.018	31.25 ab	15.25 d	4.00 a	87.50 b	1.160
Dimethoate 44EC	0.50	21.00 b	34.50 ab	84.00 b	97.50 a	1.170
Omethoate 50EC	0.50	3.75 c	10 50 d	17.50 d	48.50 c	1.040
Monocrotophos 55EC	0.50	9.50 c	12.50 d	46.00 c	56.00 c	1.078
Control		31.00 ab	37.75 ab	99.25 a	99.25 a	0.985

[z]Cultivar = AVRDC accession G 2120; planting date = 4 Oct. 1984; insecticides sprayed = 12, 15, 18, 22, 29 Oct.; 5, 12 Nov.; harvest date = 14 Jan. 1985. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test. Plot size = 10 sq m (1/1000 ha).

Antibiosis of PI 171444 to *Porthesia taiwana* and *Nezara viridula*

Introduction

In our 1982-84 studies we found three soybean accessions (PI 171451, PI 227687, and PI 229358) with various levels of resistance to defoliators such as beet armyworm, *Spodoptera exigua* (Lepidoptera: Pyralidae), *Porthesia taiwana* (Lepidoptera: Lymantriidae), *Orgyia* sp. (Lepidoptera: Lymantriidae), scarabid beetles, *Anomala cuprepis* (Coleoptera: Scarabaeidae), and three species of stinkbugs; *Nezara viridula* (Hemiptera: Pentatomidae) *Piezodorus hybneri* (Hemiptera: Pentatomidae) and *Riptortus clavatus* (Hemiptera: Coreidae).

One of these accessions, PI 227687, which has resistance to many of these pests is being used in our breeding program. In the intervening period, PI 171444 turned out to have better resistance to southern green stinkbug than PI 227687 in the U.S. We, therefore, studied the resistance of this accession to a typical defoliator, *P. taiwana*, and green stinkbug, *N. viridula*.

Materials and Methods

The feeding of *P. taiwana* larvae on PI 171444 and a susceptible check entry, TK 5 was studied. Leaves of each accession were placed in separate petri dishes. Ten 2nd-instar *P. taiwana* larvae were placed inside each petri dish. Each accession had three petri dishes each representing one replicate. The dried and eaten leaves were replaced periodically with fresh ones. Area of the leaves was measured before and after replacement. We also recorded larval mortality over a 15-day period.

In the experiment with green stinkbugs, 10 pods each of TK 5 or PI 171444 at the R5-R6 stage were placed in a petri dish. Every accession had four dishes each representing one replicate. Ten 2nd-instar nymphs were released inside each dish. The insects were allowed to feed on the pods. Old pods were replaced once every two days. Insect mortality was observed during the nymphal instars and adult stage.

Results and Discussion

P. taiwana. In the leaf-consumption study, *P. taiwana* consumed much less foliage (10.9 ± 2.6 cm^2/larva) of PI 171444 than TK 5 (18.2 ± 3.7 cm^2/larva) during the larval stage, despite the fact

that insects fed on PI 171444 had a longer larval period than on TK 5. This indicates that something in the PI 171444 foliage inhibited the feeding of *P. taiwana*.

Insecas fed on PI 171444 leaves showed a continuously increasing mortality (Fig. 1), especially between three to five days after initiation of feeding. In 15 days of observation, all insects feeding on PI 171444 died, whereas the mortality was only 62% in insects fed on TK 5. This further proves that PI 171444 foliage is antibiotic to *P. taiwana*. This soybean accession represents an additional important source of resistance to *P. taiwana*.

Green stinkbug. Insects fed on PI 171444 pods had a slightly longer nymphal period in practically all nymphal instars (Fig.2). Overall, it took 14.5 ± 1.4 days on TK 5 as against 16.0 ± 1.6 days on PI 171444 to complete the nymphal instars. Furthermore, nymph mortality on PI 171444 was substantially greater than that on TK 5 pods in all nymphal instars observed (Fig. 3). There was no difference in the proportion of adult emergence in the nymphs fed on both accessions.

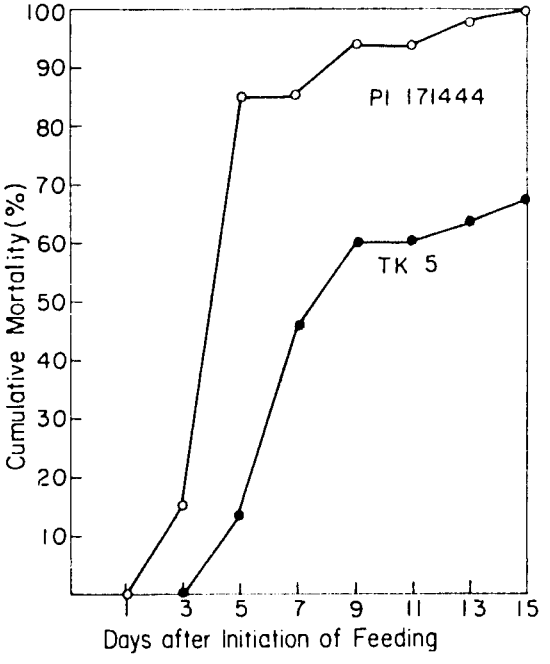

Fig. 1.
Mortality of *P. taiwana* larvae maintained on PI 171444 and TK 5 foliage.

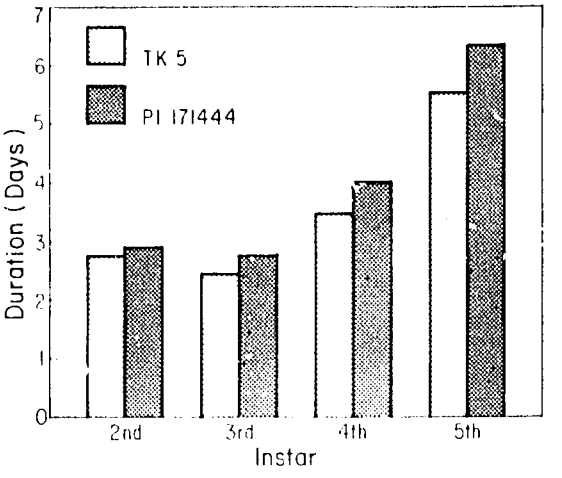

Fig 2.
Duration of various nymphal instars of *N. viridula* fed on PI 171444 and TK 5 pods.

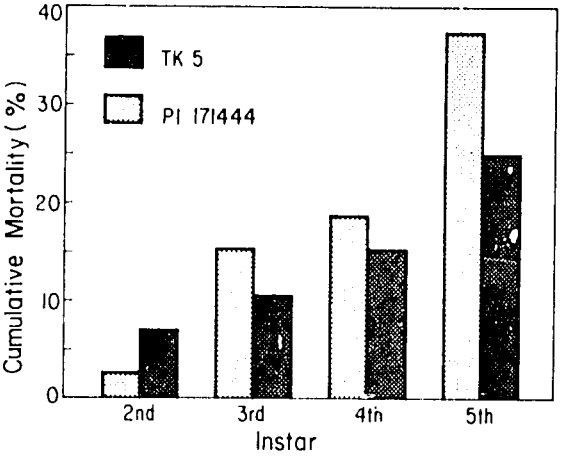

Fig. 3.
Mortality of various nymphal instars of *N. viridula* fed on PI 171444 and TK 5 pods.

Conclusion

All *P. taiwana* feeding on PI 171444 leaves died before the pupal stage, whereas those on TK 5, a susceptible cultivar, had mortality of only 62%. *N. viridula* nymphs fed green PI 171444 pods also had a considerably prolonged nymphal stage, and each nymphal stage suffered greater mortality. Accession PI 171444, thus, represents an important source of resistance to these insects.

Screening for Resistance to *Hedylepta indicata*

Introduction

A lepidopterous leaf folder, *Hedylepta indicata* (Lepidoptera: Pyralidae), infests soybean every autumn at AVRDC. The insect larvae fold two to three leaflets together and feed on them while remaining protected inside. Pupation takes place inside the leaf folds. It is a minor pest of soybean, but in 1983 its damage resulted in total defoliation of soybean plants.

In autumn 1985 it also became a serious problem; and in some instances, 100% of the unprotected plants were defoliated. The high insect population provided an excellent opportunity to screen for leaf folder resistance. Soybean germplasm that had been planted for other purposes was, therefore, screened for resistance to this insect.

Materials and Methods

After basal fertilizer application, an 0.8-ha field was rototilled and worked into 0.75-m-wide beds. Seeds of each accession were planted on the beds in a single 4-m row. Standard cultural practices were followed, except the use of insecticides. Accessions were evaluated for resistance when the leaf folder population was near its peak, and several entries had been completely defoliated. In each plot the number of damaged and healthy plants were recorded.

The percentage of damaged plants was then subjected to a statistical analysis based on mean and standard deviation (sd). Accessions which had a percentage of damaged plants under mean - 2sd were rated as highly resistant (HR); those between mean - 2sd and mean - 1sd, as moderately resistant (MR); those between mean - 1sd to mean, as possessing low resistance (LR); those between mean and mean + 2sd, as susceptible (S); and those more than mean + 2sd, as highly susceptible (HS).

Results and Discussion

All 833 accessions tested for resistance were damaged by the leaf folder. The percentage of plants damaged ranged from 16.67 to 100%. Mean percentage of plant damage was 90.95%; 647 accessions had 100% plants damaged. Based on the resistance categories, the accessions were tentatively classified as follows: 70 as HR, 59 as MR, 57 as LR, and 647 as S. Since a large number of accessions were HR, we selected those that had 25% or less damaged plants. The performance of these accessions is summarized in Table 4.

These accessions will be evaluated during autumn 1986. In the meantime, we are developing a mass-rearing technique for *H. indicata* with soybean leaves. If successful we will be able to do resistance screening, characterization, and breeding throughout the year.

Conclusion

Among 833 soybean accessions screened for *H. indicata* resistance, average plant damage was over 90%. Six accessions had less then 25% plants damaged by this pest. These accessions will be evaluated further in autumn 1986.

Table 4. Leaf folder damage to selected soybean accessions.[z]

Accession No.	Damaged Plants (%)
G 2404	16.67
G 2720	20.00
G 2914	23.08
G 2967	25.93
G 3464	19.05
G 3476	25.93
Mean (833 accessions)	90.95

[z]Planting date = 13 Sept.; evaluation date = 26 Nov. 1985.

Preliminary Screening of Soybean Germplasm for Resistance to Limabean Pod Borer

Introduction

Limabean pod borer, *Etiella zinckenella* (Lepidoptera: Pyralidae), is a serious pest of soybean in tropical to subtropical Asia. The larvae of this insect bore into the pods and feed on the developing seeds as a result of which the yield is reduced. In 1981 we found seven soybean accessions which had moderate to high levels of resistance to limabean pod borer at AVRDC. Being late maturing, they escape infestation which is seasonal in Taiwan. In areas with pod borers present throughout the year or with different seasonality than that of Taiwan, these accessions are susceptible.

To find an accession that is truly resistant, we initiated a new screening program to identify new sources of pod borer resistance. This time each accession was planted twice, once each in September and October to minimize the escape from infestation due to differences in plant maturity and pod borer season. A large number of laboratory reared pod borer pupae were also released at regular intervals to augment the ambient population. In 1985, 1,000 additional accessions were screened.

Materials and Methods

A 0.75-ha parcel of land away from areas of frequent insecticide use was rototilled, applied with fertilizer, and worked into 75-cm-wide beds. These beds were further divided into 5-m-long plots. Seeds of each of the 1,000 soybean accessions were sown in a row on a 5-m-long plot on each bed. The first planting was done on 13 September and, the second, on 11 October 1984 with the same accessions in identical plot size and design. The crop was raised according to routine cultural practices, except that no insecticide was applied.

Beginning with the flowering of the earliest flowering accessions, and at about 10-day intervals thereafter, we released a large number of laboratory reared *E. zinckenella* pupae. The pupae were placed at regular distance throughout the field. All plants in each plot were harvested at maturity, and their pods examined for limabean pod borer damage. The numbers of damaged and healthy pods were recorded and the percentage of damaged pods was calculated.

The percentage of damaged pods was analyzed by a statistical method based on mean percentage of damaged pods and standard deviation (sd) of the mean. This method enabled us to classify the accessions into various resistance categories, based on percentage of pods damaged:

Highly resistant (HR): less than mean - 2sd
Moderately resistant (MR): between mean - 2sd and mean - 1sd
With low resistance (LR): between mean - 1sd and mean
Susceptible (S): between mean and mean + 2sd
Highly susceptible (HS): greater than mean + 2sd

Results and Discussion

The classification of the accessions into various resistance categories are summarized in Table 5. Accession G 1375 was damage-free in both screenings. Since a large number of accessions fell in the MR category, we selected 18 entries which had less than 10% damage and which fell in this class in both screenings. These entries were evaluated in four monthly plantings in late 1985, the results of which will be reported in 1986.

Table 5. Distribution of soybean accessions into various resistance categories based on limabean pod borer infestation.

Resistance	Screening I		Screening II	
	No. Acc.	%	No. Acc.	%
Highly resistant	2	0.02	1	0.01
Moderately resistant	137	13.7	162	16.2
Low resistance	440	44.0	393	39.3
Susceptible	279	27.9	295	29.5
Highly susceptible	142	14.2	149	14.9
Total	1000	100	1000	100
Mean % damage	16.87		21.05	
Standard deviation	7.20		8.98	
Range of damage	0 to 49.15		0 to 57.03	

Conclusion

Among 1,000 accessions screened, 19 soybean accessions showed moderate to high levels of resistance to limabean pod borer in two plantings in a preliminary nonreplicated screening. These accessions are being evaluated further to confirm their resistance.

Confirmation of Resistance to Limabean Pod Borer in Selected Soybean Accessions

Introduction

Limabean pod borer, *Etiella zinckenella* (Treit), (Lepidoptera: Pyralidae) is one of the most destructive pests of soybean in tropical Asia. Its habit of boring into the pod to feed on the seeds reduces yield and also makes it difficult to control by conventional insecticide application. At AVRDC, therefore, we initiated a screening program to find sources of resistance in order to breed pod-borer-resistant soybean cultivars.

In 1981 seven cultivars were identified with a resistance that was merely due to late maturity which enabled them to escape the infestation. In a new screening program the same cultivars were planted twice (in September and October), and laboratory-reared insects released to overcome the escape problem. Using this method, we screened 1,000 accessions in 1983 and selected 17 which were least damaged in the two screenings. This study is a three-replicated trial to confirm the resistance of these accessions.

Materials and Methods

The planting area was rototilled and worked into 0.75-m-wide beds. Each plot was a 10-m-long bed. Seeds of the 17 apparently resistant and three susceptible accessions were sown on each bed. Each accession was planted in three randomly selected beds. There were three plantings: one each in

August, September, and October. The crop was raised according to standard cultural practices, except that no insecticide was applied.

Starting from the date of flowering of the earliest-flowering accession, we released laboratory-reared *E. zinckenella* pupae at intervals to augment the native insect population. At harvest, we collected all pods in each plot and counted the number of damaged and healthy pods. The percentage of damaged pods were analyzed by Duncan's multiple range test to select the least-damaged accessions.

Results and Discussion

The results of pod borer infestation in three screenings are presented in Table 6. The percentage of damaged pods increased from first screening to third screening, possibly because of increased pod borer population resulting from frequent insect release. Accessions G 98, G 100, and G 111 were least damaged in all three screenings.

Table 6. Limabean pod borer infestation of selected soybean accessions in three plantings of the second resistance screening.[z]

Accession	Pod Damage (%)		
	Screening 1	Screening 2	Screening 3
1. G 57	9.58 bc	6.90 gf	16.03 e
2. G 92	9.38 bc	8.00 defg	31.70 de
3. G 93	8.40 bc	6.05 fg	31.02 bcde
4. G 97	8.10 bc	6.72 fg	17.38 e
5. G 98	6.44 c	6.68 fg	16.18 e
6. G 100	6.17 c	6.86 fg	16.11 e
7. G 104	8.65 bc	7.30 efg	25.05 cde
8. G 110	6.65 c	8.15 defg	16.15 e
9. G 111	6.12 c	3.46 g	16.31 e
10. G 112	10.23 bc	12.04 cdef	27.43 cde
11. G 114	8.94 bc	7.62 defg	24.40 de
12. G 117	9.28 bc	7.33 efg	16.87 e
13. G 118	8.27 bc	6.98 fg	20.38 de
14. G 127	14.21 abc	13.17 cde	43.49 abc
15. G 222	12.18 bc	25.59 ab	21.70 de
16. G 306	23.18 bc	16.96 c	47.60 ab
17. G 584	18.48 ab	13.43 cd	29.50 bcde
18. G 2808	24.62 a	22.64 b	54.90 a
19. G 972	19.59 ab	26.05 ab	15.17 e
20. G 1207	23.01 a	29.16 a	39.33 abcd

[z]Planting dates: screening 1 – 24 Aug., screening 2 – 13 Sept., screening 3 – 12 Oct. 1984.

The analysis of pod-damage data for possible correlation between the number of pods per plant and the percentage of pods damaged revealed that plants with more pods had lesser percentage of pods damaged (Fig. 4). The correlation between these two parameters was highly significant in each of the three plantings. The least damaged three accessions generally had a higher number of pods per plant than the remaining entries. These accessions are, thus, not truly resistant materials; therefore, the search must continue.

Conclusion

Three accessions were consistently least damaged by limabean pod borer in three monthly screenings during 1984. Less damage was associated with greater number of pods per plant rather than with true resistance. Our search for pod borer resistance must continue into the future.

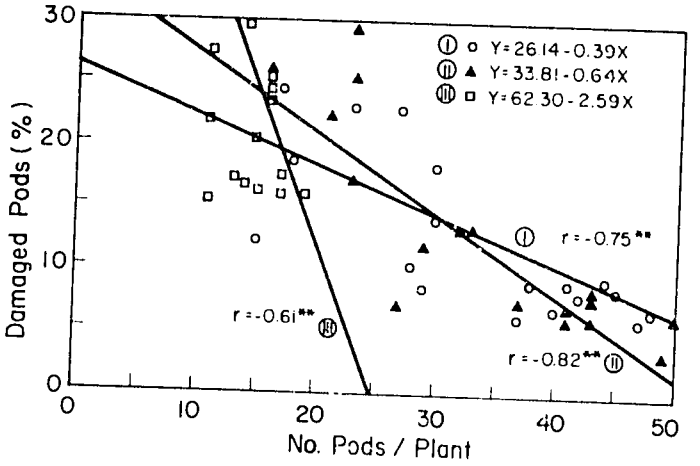

Fig. 4.
Correlation of limabean pod borer damage to soybean pods and the number of pods per plant in three resistance screening trials.

Oviposition Behavior of Limabean Pod Borer

Introduction

Limabean pod borer, *Etiella zinckenella* (Lepidoptera: Pyralidae) is a serious pest of soybean and certain other legumes in tropical to subtropical Asia, especially in Indonesia where, at times, up to 80% yield reduction is sustained. Once the larva starts feeding on the developing seeds, it rarely moves from one pod to the other; hence, the selection of oviposition site by the adult moths is crucial in insect infestation.

In some cases an oviposition deterrent plays an important role in the mechanism of insect resistance. We have been screening soybean germplasm to find sources of resistance to limabean pod borer. In this connection, we studied the insect's oviposition behavior in 1984, particularly on the soybean plant parts and growth stages most preferred for oviposition.

Materials and Methods

The study to determine the preferred plant parts for oviposition was done in a soybean field where laboratory-reared limabean pod borer pupae were released to augment insect population for resistance screening. The guard row of this 0.8-ha field was planted with soybean cultivar KS 9 on which we made observations.

Twice every week, 30 plants at the R5 to R6 stages were uprooted; and pods, inflorescences, stems, and leaves were observed for pod borer eggs. The number of eggs on the upper, middle, and bottom third of the plant was recorded.

The study on the preferred plant-growth stage for oviposition was conducted in a greenhouse. The soybean plants were raised in clay pots continuously by sowing seeds once a week and maintaining them until harvest. Based on the results of an earlier field study which indicated that limabean pod borer preferred soybean pods for oviposition, two potted plants at the R5, R6, R7 and R8 growth stages each were placed in four large nylon-net cages.

Fifty pairs of laboratory-reared limabean pod borer adults were released inside each cage. Five days later, the number of eggs on the pods in the upper, middle, and lower third of each plant were recorded. The insect-count data were analyzed by Duncan's multiple range test.

Results and Discussion

The results of the field study on the plant-part preference for limabean pod borer oviposition are summarized in Table 7. Eggs were found only on pods and stems closer to the pods. Out of 209 plants

166 had limabean pod borer eggs. An overwhelming (94%) number of them were on the pods; 75% of the eggs were on the pods in the upper one-third of the soybean plants.

In the study on the preferred plant-growth stage for oviposition, therefore, we observed the eggs only on the pods. The data on number of eggs on the pods of plants at the R5 to R8 growth stages are presented in Table 8. The limabean pod borer laid more eggs on pods of R5 to R7 plants than on the pods of older plants in the upper one-third of the plant. More eggs were found on the pods of R6 plants than on those of R5 or R7 stage plants. There were no significant differences in the numbers of eggs laid on pods of R5 to R8 plants located in the middle or lower parts of the plant. This could be due to the fact that, in general, fewer eggs were found on pods in those sections of the plant.

Table 7. Limabean pod borer oviposition on various parts of soybean plants.

Plant Section	No. of Eggs on	
	Pods	Stems
Upper	205	8
Middle	68	9
Lower	1	0

Table 8. Limabean pod borer oviposition on soybean plants of various growth stages.[z]

Growth	No. Eggs on Pods in Plant Section		
Stage	Upper	Middle	Lower
R5	19.0 ab	12.0 a	5.0 a
R6	26.5 a	16.0 a	3.0 a
R7	18.5 ab	17.5 a	2.0 a
R8	15.0 b	13.5 a	5.5 a

[z]Data are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Conclusion

A survey of a large number of plants for oviposition characteristics indicated that the limabean pod borer prefers to lay eggs on the pods in the upper one-third of the plant. Among the plants at R5 to R8 growth stages, the insect preferred to lay eggs on R5 to R7. Pods of R6 plants had more eggs than those of other growth stages.

Soybean Pathology

Advanced Soybean Rust Tolerance Trial

Introduction

A series of trials, preliminary (PRTT), intermediate (IRTT), and advanced (ARTT), have been conducted to evaluate and select lines with improved levels of rust tolerance, high yield, and early maturity. Selected lines from the IRTT are advanced to the ARTT, and the best lines from the ARTT will be tested in selected countries worldwide where soybean rust is a serious problem.

Materials and Methods

One advanced rust tolerance trial (ARTT) was conducted in fall 1984 and two (ARTT-I & ARTT-II), in spring season 1985. Seven advanced lines previously selected for rust tolerance and high yield potential, as well as three check cultivars (G 38, AGS 129, and AGS 181) were planted in fall 1984 (ARTT) and spring season 1985 (ARTT-I). Nineteen advanced lines, previously selected for high yield potential and moderate to high levels of tolerance under a rust epidemic, were planted in ARTT-II of spring 1985 with five check cultivars (G 38, AGS 129, AGS 181, KS 8, and PI 459025).

Plot size for each line or cultivar was 3 x 6 m (2 x 5 m harvested area), and plant density was equivalent to 400,000 plants/ha. A split-plot design with four replications was used. Main plots were fungicide and non-fungicide treatments; subplots were advanced lines and check cultivars. The 1984 fall ARTT was planted on 18 September, and the nonfungicide plots were inoculated with rust on 18 and 23 October. ARTT-I and ARTT-II were planted from 26 to 28 February 1985, and the nonfungicide plots were inoculated with rust on 9 and 15 April. The fungicide-protected plots were sprayed with Dithane M 45 every two weeks. AVRDC cultural practices were followed.

Data collected included yield, 100-seed weight, days to maturity, defoliation, and percentage of rust severity. Yield data were converted to 13% moisture content before evaluation, and yield loss was expressed as percentage of fungicide-protected yield. Rust severity and defoliation were estimated in percentage. The rate of rust development was the regression coefficient of the correlation between logit of total rust-affected foliage (rust-affected foliage + defoliation) and relative lifetime (DAP x 100/days to R8). The criteria for line selection is a yield similar to or better than G 38 with fungicide protection, a yield similar to or better than AGS 181 without fungicide treatment, and a tolerance level better than G 38.

Four of the lines and three of the check cultivars included in these ARTT's were previously included in four rust-tolerance trials in three locations: AVRDC (two trials), Hualien DAIS (one trial), and Chiang Mai FCRS, Thailand. The check cultivar AGS 129 was not included in one of the AVRDC trials. Yield and tolerance evaluations of these four trials were reported in 1984. The yield data from all six trials (1983-85) were combined for an evaluation of tolerance and yield stability across environments. Twelve environmental indices (six locations X 2 treatments, with and without fungicide) were determined for the stability study. Regression analysis was used with environmental index as the independent variable and yield as the dependent variable.

Results and Discussion

ARTT (fall 1984) and ARTT-I (spring 1985). In both trials, five of the best lines had tolerance levels (based on percentage of yield loss) that were similar to or better than AGS 181, the highly tolerant check cultivar (Table 1). All of these lines yielded similar to or better than G 38 (the standard yield check) in the fungicide-protected treatment.

Rate of rust development ranged from 0.1138 to 0.2307 in fall and ranged from 0.0686 to 0.1395 in spring. The estimated rust-affected foliage at 70% completion of the soybean life cycle ranged from 22.03 to 49.3% in the fall and from 21.19 to 33.92% in spring season.

The yield stability data for four of the lines in the ARTT and ARTT-I across 12 environments appear in Table 2. All of the test lines were similar to each other and had a higher mean yield than the check cultivars, as well as a more acceptable regression coefficient closer to the theoretical optimum for stability (b = 1). The best line appeared to be GC 60087-7-9-6-11-46, which had the highest mean yield, the lowest deviation from the regression line (S^2d), and a regression coefficient closest to the ideal of 1.0. The advantage of this line can be seen in Fig. 1. GC 60087-7-9-6-11-46 yielded 8.3% more than G 38 with fungicide protection and 9.4% better than AGS 181 without it. The level of tolerance (percentage of yield loss) in the six trials for this line was 31.3% as compared to 26.1% for AGS 181 and 40.0% for G 38.

Table 1. Yield and yield loss percentage of advanced lines in the ARTT (fall 1984) and ARTT-I (spring 1985) under fungicide-protected and unprotected conditions during a soybean rust epidemic, AVRDC.[z]

Cultivars	ARTT Yield (t/ha)		ARTT-I Yield (t/ha)		Yield Loss %	
	F[y]	NF[y]	F[y]	NF[y]	ARTT	ARTT-I
GC 60082-8-14-6-7-68	2.64	1.17	2.37	2.39	55.58	0.00
GC 60087-7-9-6-10-31	2.47	1.36	2.53	2.3	44.67	11.72
GC 60087-7-9-6-11-46	2.88 +	1.36	2.61	2.34 +	52.94	10.52
GC 60087-7-9-6-12-8	2.74 +	1.54 +	2.32	2.20	43.68	5.11
GC 60087-7-9-6-12-52	2.47	1.46 +	2.56	2.29 +	40.84	10.76
B-15-0-0-0-9-Bk-1e-Bkt-1-Bk-Bk	2.34	1.57 +	2.63	2.28	32.82	13.15
B-15-0-0-0-9-Bk-1e-Bkt-3-Bk-Bk	2.59	1.55 +	2.65	2.32	40.09	10.91
G 38 (check)	2.49	0.92 -	2.48	2.12	63.12	14.30
AGS 129 (check)	2.97 +	0.86	2.64	1.50 -	71.20	43.26
AGS 181 (check)	2.31	1.28	2.32	2.03	44.51	12.40
LSD .05	0.182		0.228			

[z]Advanced rust tolerance trials, plot size of each cultivar is 3 x 6 m; plant density is equivalent to 400,000 plants/ha. [y]F = fungicide protected, NF = unprotected. + = significantly greater than the check (G38); - = significantly less than the check (G 38); numbers without symbols = no significant difference from G 38. + = significantly greater than the check (AGS 181); - = significantly less than the check (AGS 181); numbers without symbols = no significant difference from AGS 181.

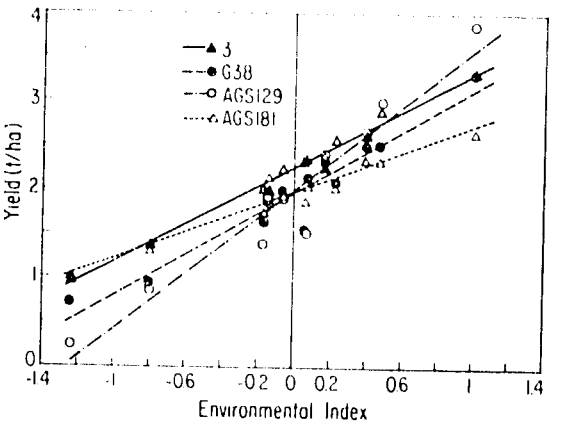

Fig. 1.
Comparative yield stability of four cultivars across 12 environments (6 rust-tolerance trials X 2 treatments, with and without fungicide protection), 1983-85.

Table 2. Means and stability parameters for yield (t/ha) across 12 environments in advanced rust tolerance trials, 1983-1985.[z]

Entry	Mean	b	S^2d
GC 60087-7-9-6-11-46	2.23	1.070	0.0856
GC 60082-8-14-6-7-68	2.20	0.918	0.1545
GC 60087-7-9-6-12-52	2.17	0.912	0.1519
GC 60087-7-9-6-12-8	2.17	0.889	0.1252
AGS 129	1.96	1.580	0.2808
AGS 181	1.96	0.756	0.1489
G 38	1.95	1.170	0.1989

[z]Six locations x two treatments, with and without fungicide; b = regression coefficient; S^2d = deviation from regression.

ARTT-II (spring 1985). The yields of three best lines were significantly better than that of G 38 in the fungicide-protected treatment and AGS 181 in the unprotected plots (Table 3). The yields of these three lines were not significantly different from KS 8 (highest-yielding check) with fungicide protection. All test lines yielded similarly or better than AGS 181 without protection; 12 of them are more tolerant than AGS 181. Five test lines had a higher level of tolerance than AGS 181 and yielded significantly better in both the fungicide and nonfungicide treatments.

Table 3. Yield and yield loss percentage of advanced breeding lines in the advanced rust tolerance trial (ARTT-II) under fungicide-protected and unprotected conditions during a soybean rust epidemic, spring 1985, AVRDC.

Cultivars	Yield (t/ha)[z] protected[y]	Yield (t/ha)[z] unprotected[x]	Yield Loss (%)
B-15-0-0-0-9-Bk-1e-Bkt-1-Bk-Bk	2.77	2.38 +	13.96
B-15-0-3-2-1-Bk-2e-Bkt-2-Bk-Bk	2.14 –	2.15 +	0.00
B-15-0-3-2-1-Bk-2e-Bkt-4-Bk-Bk	2.30 –	2.16 +	5.92
B-15-0-3-2-1-Bk-2e-Bkt-8-Bk-Bk	2.24 –	2.13	4.91
B-15-0-3-1-3-Bk-2e-Bkt-6-Bk-Bk	2.88	2.49 +	13.40
C-22-0-Bk-Bke-Bke-2e-1-4-Bk-Bk	2.40 –	2.05	14.56
C-22-0-Bk-Bke-Bke-2e-2-3-Bk-Bk	2.47 –	2.10	15.22
C-33-0-Bk-Bke-Bkl-2e-1-2-Bk-Bk	2.48 –	1.90	23.43
C-57-0-Bk-Bke-Bkl-3e-2-3-Bk-Bk	2.62	2.23 +	14.56
C-22-0-Bk-Bke-Bkl-5e-1-2-Bk-Bk	2.34 –	2.01	14.03
C-56-1-Bk-Bke-Bkl-1e-1-1-Bk-Bk	2.68	2.11	21.42
D-18-0-Bke-3e-1-4-Bk-Bk	2.82	2.27 +	19.50
D-14-0-Bkl-6e-5-2-Bk-Bk	2.99	2.60 +	13.13
B-15-0-0-0-9-Bk-1e-Bkt-3-Bk-Bk	2.85	2.38 +	16.48
D-11-3-Bke-1e-1-1-Bk-Bk	2.81	2.13	24.34
D-11-3-Bke-1e-10-1-Bk-Bk	3.07 +	2.23 +	27.42
D-11-3-Bke-1e-10-2-Bk-Bk	3.19 +	2.17 +	31.88
D-14-0-Bkl-1e-1-1-Bk-Bk	2.76	2.22 +	19.50
D-14-0-Bkl-6e-1-2-Bk-Bk	3.44 +	2.39 +	30.51
G 38 (check)	2.83	2.00	29.27
AGS 129 (check)	2.98	1.63 –	45.30
AGS 181 (check)	2.33 –	1.91	17.87
KS 8 (check)	3.29 +	2.00	39.16
PI 459025 (check)	2.54 –	2.06	18.68
LSD .05	0.239		

[z]Plot size of each cultivar is 3 x 6 m; plant density is equivalent to 400,000 plants/ha. [y]+ = significantly greater than the check (G 38); – = significantly less than the check (G 38); numbers without symbols = no significant difference from G 38. [x]+ = significantly greater than the check (AGS 181); – = significantly less than the check (AGS 181); numbers without symbols = no significant difference from AGS 181.

Rate of rust development ranged from 0.0889 to 0.1820, and the estimated rust-affected foliage at 70% completion of the soybean life cycle ranged from 9.92 to 40.03%.

A combined evaluation of the lines that were included in both the IRTT's (fall 1984) and ARTT-II (spring 1985) indicated that several lines were very promising with respect to levels of tolerance and yield. Three lines had mean tolerance levels (yield loss 18 to 25%) distinctly better than AGS 181 (yield loss 33%), the highly tolerant check, and mean yield levels (33 to 39%) higher than AGS 181 without fungicide protection and similar to or higher (0 to 7% increase) than G 38 with protection. The mean yield of AGS 129 is 11% higher than that of G 38 with fungicide protection. These three lines are "B-15-0-0-0-9-Bk-1e-Bkt-1-Bk-Bk", "B-15-0-0-0-9-Bk-1e-Bkt-3-Bkt-Bkt", and "B-15-0-3-1-3-Bk-2i-Bkt-6-Bk-Bk".

Another two lines, D-14-0-Bkt-6e-1-2-Bk-Bk and D-14-0-Bkt-6e-5-2-Bk-Bk, were also promising. Their tolerance levels (yield loss 38 and 30%) were intermediate between AGS 181 (27%) and G 38 (41%); however, their mean yield levels were 38 and 24% higher than those of G 38 with fungicide protection, and 32 and 34% higher than AGS 181 without it. The mean yield of AGS 129 is only 13% better than that of G 38 with fungicide protection and its associated yield loss was 49%.

Conclusion

In a combined analysis of four lines in six trials, line GC 60087-7-9-6-11-46 showed superiority in yield stability and mean yield across 12 environments. Among the 19 lines, three lines had tolerance levels higher than that of AGS 181 and yield similar to or better than that of G 38 with fungicide protection. Two other lines had tolerance levels intermediate between AGS 181 and G 38 and yielded far better than G 38 with fungicide protection and AGS 181 without it.

Intermediate Soybean Rust Tolerance Trial

Introduction

Previous results showed that a significant variation in relative yielding ability exists among soybean cultivars under stress from a rust epidemic (tolerance). Therefore, a series of rust tolerance trials, preliminary (PRTT), intermediate (IRTT) and advanced (ARTT), have been established to evaluate and select soybean lines with improved levels of tolerance to rust, high yield, and early maturity. Selected lines from the IRTT are advanced to the ARTT.

Materials and Methods

Three intermediate rust tolerance trials (IRTT-I, IRTT-II, and IRTT-III) were conducted in fall 1984. Sixteen D-lines, 11 C-lines and 11 B-lines were previously selected from intermediate trials in spring 1984 on the basis of uniform morphology, resistance to lodging, potential tolerance to rust, and potential high yield under severe rust stress. These lines were planted with five check cultivars (G 38, AGS 129, AGS 181, KS 8, and TK#1). Plot size for each line or cultivar was 3 x 4 m (2 x 3 m harvested area), and plant density was equivalent to 200,000 plants/ha.

A split-plot design with three replications was used. Main plots were fungicide-protected and unprotected treatments; subplots were advanced lines and check cultivars. All three experiments were planted on 19 September 1984, and the unprotected plots were inoculated with rust on 18 and 23 October 1984. The fungicide-protected plots were sprayed with Dithane M-45 each two weeks. AVRDC cultural practices were followed.

Data collected included yield, 100-seed weight, and days to maturity. Yield data were converted to 13% moisture content before evaluation; yield loss was expressed as percentage of fungicide-protected yield.

Results and Discussion

In the IRTT-I trials, the yield of all test lines were significantly higher than that of G 38 (yield check) in the fungicide-protected treatment (Table 4). Five of these lines also yielded significantly higher than AGS 181 (highly tolerant check) in the unprotected treatment. Yield loss (tolerance) of all 16 lines was lower than or similar to that of G 38. Ten lines had high relative yield in both fungicide-protected and unprotected treatments.

Table 4. Yield and yield loss percentage of advanced breeding lines in the intermediate rust tolerance trial (IRTT-I) under fungicide-protected and unprotected conditions during a soybean rust epidemic, fall 1984, AVRDC.

Cultivars	Yield (t/ha)[z] protected[y]	Yield (t/ha)[z] unprotected[x]	Yield Loss (%)
D-11-3-Bke-1e-1-1-Bk-Bk	2.27 +	1.20	47.15
D-11-3-Bke-1e-5-1-Bk-Bk	2.45 +	1.03	57.93
D-11-3-Bke-1e-9-1-Bk-Bk	2.50 +	1.02	59.36
D-11-3-Bke-1e-9-5-Bk-Bk	2.33 +	0.99	57.67
D-11-3-Bke-1e-10-1-Bk-Bk	2.44 +	1.24	49.16
D-11-3-Bke-1e-10-2-Bk-Bk	2.22 +	1.20	46.07
D-18-0-Bke-1e-1-2-Bk-Bk	2.16 +	1.19	44.60
D-18-0-Bke-3e-1-4-Bk-Bk	2.36 +	1.45 +	38.53
D-18-0-Bke-4e-1-3-Bk-Bk	2.35 +	1.36 +	42.16
D-14-0-Bkl-1e-1-1-Bk-Bk	2.48 +	1.25	49.53
D-18-0-Bkl-1e-2-2-Bk-Bk	2.44 +	1.10	54.81
D-18-0-Bkl-1e-3-3-Bk-Bk	2.46 +	1.09	55.75
D-14-0-Bkl-6e-1-2-Bk-Bk	3.01 +	1.60 +	46.69
D-14-0-Bkl-6e-3-5-Bk-Bk	2.41 +	1.40 +	41.62
D-14-0-Bkl-6e-5-2-Bk-Bk	2.79 +	1.47 +	47.34
D-11-3-Bkl-7e-2-1-Bk-Bk	2.43 +	1.07	56.01
G 38 (check)	1.84	0.78 −	57.80
AGS 129 (check)	2.28 +	0.77 −	66.02
KS 8 (check)	2.50 +	0.79 −	68.29
AGS 181 (check)	1.80	1.12	37.95
TN 4 (check)	2.55 +	0.97	61.88
LSD	0.223		

[z]Plot size of each cultivar is 4 × 3 m; plant density is equivalent to 200,000 plants/ha; [y] + significantly greater than the check (G38); − significantly less than the check (G38); numbers without symbols = no significant difference from G 38. [x] + significantly greater than the check (AGS 181); − significantly less than the check (AGS 181); numbers without symbols = no significant difference from AGS 181.

Two lines, D 14-0-BKl-6e-1-2-Bk-Bk and D 14-0-Bkl-6e-5-2-Bk-Bk, yielded significantly better than TN #4 (highest yielding check) with fungicide treatment and significantly better than AGS 181 without it. These two lines had good yields in the fall season, regardless of the presence or absence of rust. One line, D 18-0-Bke-3e-1-4-Bk-Bk, represented a level of tolerance similar to that of AGS 181.

In the IRTT-II trials, three of the 11 test lines yielded significantly higher than G 38 (yield check), including one line that yielded significantly better than AGS 129 with fungicide protection (Table 5). Yield losses of 10 lines were lower than that of G 38; those of four of these lines were also lower than that of AGS 181. One line, C 33-0-Bk-Bke-Bkl-2e-1-2-Bk-Bk, had a yield similar to that of TN #4 (highest-yielding check) in the fungicide-protected treatment and was the highest-yielding cultivar without fungicide, with a level of tolerance similar to that of AGS 181. This line showed great potential for the fall season.

In the IRTT-III, four lines yielded significantly better than G 38 in the fungicide-protected treatment (Table 6). Ten of the 11 test lines significantly outyielded all check cultivars without fungicide protection. Yield losses of the test lines ranged from 25.98 to 45.38 and were all lower than that of AGS 181 (highly tolerant check).

Table 5. Yield and yield loss percentage of advanced breeding lines in the intermediate rust tolerance trial (IRTT-II) under fungicide-protected and unprotected conditions during a soybean rust epidemic, fall 1984, AVRDC.

Cultivars	Yield (t/ha)[y]		Yield
	protected[y]	unprotected[x]	Loss (%)
C-22-0-Bk-Bke-Bke-2e-1-2-Bk-Bk	2.05 +	1.15	43.88
C-22-0-Bk-Bke-Bke-2e-1-4-Bk-Bk	1.91	1.20	37.14
C-22-0-Bk-Bke-Bke-2e-2-3-Bk-Bk	2.15 +	1.18	45.23
C-41-0-Bk-Bke-Bke-3e-2-4-Bk-Bk	1.58 –	1.07	32.29
C-33-0-Bk-Bke-Bke-2e-1-2-Bk-Bk	2.39 +	1.33 +	44.26
C-56-1-Bk-Bke-Bke-2e-2-3-Bk-Bk	1.95	1.12	42.56
C-56-1-Bk-Bke-Bke-2e-2-4-Bk-Bk	1.88	1.04	44.59
C-57-0-Bk-Bke-Bke-3e-2-3-Bk-Bk	1.79	1.17	34.41
C-22-0-Bk-Bke-Bke-5e-1-2-Bk-Bk	2.03	1.20	41.10
C-56-1-Bk-Bke-Bkt-1e-1-1-Bk-Bk	2.01	1.23	39.02
00031-Bk-Bke-3e-1-2-1-Bk	1.66	0.69 –	58.32
G 38 (check)	1.82	0.79 –	56.68
AGS 129 (check)	2.13 +	0.76 –	64.41
KS 8 (check)	2.38 +	0.83	64.97
AGS 181 (check)	1.81	1.05	41.90
TN 4 (check)	2.43 +	1.09	55.30
LSD .05	0.228		

For footnotes, please refer to Table 4.

Table 6. Yield and yield loss percentage of advanced breeding lines in the intermediate rust tolerance trial (IRTT-III) under fungicide-protected and unprotected conditions during a soybean rust epidemic, fall 1984, AVRDC.

Cultivars	Yield (t/ha)[y]		Yield
	protected[y]	unprotected[x]	Loss (%)
B-15-0-0-0-3-Bk-1e-Bkt-Bk-7-Bk	1.70	1.23 +	27.76
B-15-0-0-0-9-Bk-1e-Bkt-1-Bk-Bk	1.79	1.36 +	24.12
B-15-0-0-0-9-Bk-1e-Bkt-3-Bk-Bk	2.03 +	1.29 +	36.49
B-15-0-0-0-9-Bk-1e-Bkt-6-Bk-Bk	1.80	1.25 +	30.71
B-15-0-3-2-1-Bk-2e-Bkt-1-Bk-Bk	2.07 +	1.13 +	45.38
B-15-0-3-2-1-Bk-2e-Bkt-2-Bk-Bk	1.84	1.22 +	34.05
B-15-0-3-2-1-Bk-2e-Bkt-4-Bk-Bk	1.90	1.20 +	36.76
B-15-0-3-2-1-Bk-2e-Bkt-5-Bk-Bk	1.94 +	1.14 +	41.06
B-15-0-3-2-1-Bk-2e-Bkt-8-Bk-Bk	1.94 +	1.19 +	38.55
B-15-0-3-2-1-Bk-2e-Bkt-Bk-1-Bk	1.45 –	0.91	37.07
B-15-0-3-1-3-Bk-2e-Bkt-6-Bk-Bk	1.82	1.35 +	25.98
G 38 (check)	1.74	0.67 –	61.42
AGS 129 (check)	2.11 +	0.82	61.02
KS 8 (check)	2.32 +	0.65 –	72.09
AGS 181 (check)	1.79	0.86	51.85
TN 4 (check)	2.22 +	0.79	64.30
LSD .05	0.188		

For footnotes, please refer to Table 4.

Conclusion

In these three trials containing 38 lines, the level of tolerance was based on the rust-induced yield loss in the plots without fungicide protection in comparison to that with protection. Nineteen lines were selected for further evaluation in the advanced rust tolerance trials in 1985.

Screening for Downy Mildew Resistance in Soybean

Introduction

Downy mildew, caused by the fungus *Peronospora manshurica* (Naum.) Syd. ex Gaum., is one of the most common diseases of soybeans. Disease development is favored by high humidity and temperatures of 20 to 24°C. It causes defoliation, lower seed quality, reduced seed size, and yield losses. The disease can be controlled by spraying with fungicides and growing resistant cultivars. This experiment was designed to screen AGS lines and accessions for resistance to downy mildew.

Materials and Methods

A total of 360 soybean AGS lines and accessions were tested for resistance to downy mildew in spring 1985. Among these there were 129 AGS lines selected from AGS 1 to 180 as symptomless in the last screening test, 109 lines from AGS 181 to 290 tested for the first time for downy mildew resistance, 86 accessions previously identified as resistant, and 36 vegetable soybean accessions. Check cultivars were G 38 (highly resistant), AGS 66 (moderately resistant) and AGS 191 (highly susceptible).

Test lines and accessions were planted in 1 x 1 m plots, and check cultivars were planted at intervals after every 10 lines. Three 1 x 1 m plots for each check cultivar were arranged together; AGS 191 was planted in the middle, and G 38 and AGS 66 were planted on either side. A randomized complete block design with two replications was used. The trial was planted on 3 March 1985. Check cultivars were inoculated with a downy mildew spore suspension collected from AVRDC fields on 4 April. The whole experimental area was inoculated on 3 and 17 May with inoculum collected from Pingtung. AVRDC cultural practices were followed.

Disease severity was evaluated as percentage of disease-affected leaf area per plot. Disease ratings were established by comparing the disease severity of test lines with the nearest check cultivars. Disease severity was rated on 30 May, as follows:

2: disease severity < G 38 (highly resistant check)
3: G 38 < disease severity < AGS 66 (moderately resistant check)
4: disease severity = AGS 66
5-7: AGS 66 < disease severity < AGS 191 (highly susceptible check)
8: disease severity = AGS 191
9: disease severity > AGS 191

Results and Discussion

Most test lines were as highly resistant as G 38 (disease severity = 0), including 129 AGS lines, 22 vegetable soybeans, and 58 accessions (Table 7). A quarter of test lines were moderately resistant, with disease severities lower or similar to that of moderately-resistant check AGS 66 (disease severity = 1%). No more than 20% of the test lines in any group rated from 5 to 9, disease severities higher than that of AGS 66. Only six test lines (5 AGS lines and 1 accession) rated 8 or 9 and were, therefore, as highly or more highly susceptible than AGS 191 (disease severity = 30%).

Only 74 lines of the 129 AGS lines, previously selected from AGS 1 to 180 as symptomless, appeared symptomless in this trial. The other 55 of these AGS lines were affected by downy mildew. Thirty-five lines were rated 3 or 4 (moderately resistant). Twenty lines had a higher disease severity than AGS 66. AGS 119 was rated 8 and therefore highly susceptible.

Among 86 accessions previously identified as resistant, 28 accessions were affected by downy mildew. Seven of these accessions had higher disease severities than AGS 66 and were rated moderately to highly susceptible. Among the vegetable soybeans 78% were rated moderately to highly resistant.

Table 7. Disease rating and number of soybean test lines for resistance screening to downy mildew.

Entries	Resistance Rating[z]			
	2	3	4	5-9
AGS lines[y]	129 (54.2)	38 (16.0)	24 (10.1)	47 (19.7)
Fresh soybeans[y]	22 (61.1)	6 (16.7)	2 (5.6)	6 (16.7)
Accessions[y]	58 (67.4)	14 (16.3)	7 (8.1)	7 (8.1)
Total[x]	209 (58.1)	58 (16.1)	33 (9.2)	60 (16.7)

[z]Resistance ratings are the mean of two replications: 2 = disease severity similar to G 38; 3 = disease severity higher than G 38 and lower than AGS 66; 4 = disease severity similar to AGS 66; 5-9 = disease severity higher than AGS 66. [y]Each figure in parenthesis is the percentage of each group of test lines. [x]Each figure in parenthesis is the percentage of total test lines.

Conclusion

A downy mildew resistance-screening trial with 360 test cultivars and three checks, which represented the expected levels of resistance or susceptibility, was planted in spring 1985. The majority of the AGS lines tested were rated as moderately to highly resistant to downy mildew.

Screening for Resistance to Bacterial Pustule

Introduction

Bacterial pustule caused by *Xanthomonas campestris* pv. *glycines*, is one of the most important diseases in Southeast Asia when soybeans are grown during the rainy season. The disease reduces photosynthetic capacity and causes premature defoliation, resulting in fewer, smaller seeds and yield losses. Significant differences in varietal reaction to the disease were found in the 1984 screening test. This trial evaluated the highly/moderately resistant accessions and AGS lines to confirm their resistance to bacterial pustule. It also evaluated some lines which were rated as tolerant to soybean rust in the previous studies.

Materials and Methods

Forty-one AGS lines, 37 accessions, and 26 breeding lines were planted in 1 x 1 m plots at a plant density equivalent to 200,000 plants/ha with three replications. The check cultivars were G 8190 (highly resistant), CNS (moderately resistant), and G 38 (highly susceptible). The experiment was planted on 18 July 1985 and artificially inoculated on 14 August 1985.

The inoculum was prepared by homogenizing seriously infected soybean leaves in a blender and then filtering the homogenate through two layers of nylon net to obtain a bacterial cell suspension. The suspension was then diluted in water and a sticker-spreader (1:1000) was added. Inoculation was accomplished by forcibly spraying the dilute suspension against both leaf surfaces with an atomizer attached to a high pressure (25 kg/cm^2) pump.

Disease ratings were made three weeks following inoculation and again 15 days later. Resistance evaluation was based on the following rating system: highly resistant (HR) = disease severity similar to or less than G 8190; highly resistant (HR-) = disease severity slightly more than G 8190; moderately resistant (MR) = disease severity similar to G 2034 (CNS); moderately susceptible (MS) = disease severity distinctly more than G 2034 and less than G 38; and highly susceptible (HS) = disease severity similar to or greater than G 38.

Results and Discussion

Thirty-three cultivars, 13 AGS lines, and 20 germplasm accessions were rated highly resistant to bacterial pustule (Table 8). Eight of these AGS lines were the result of the crossing program (GC lines), and the other five lines were accessions selected as AGS lines. All of these eight highly-resistant AGS lines were derived from two crosses, seven lines from SRF 400 X PI 297550, and one line from Essex X TN#4 (Table 9). The pedigree of Essex is S-100/CNS//Roanoke//Ogden /CNS//Perry.

Table 8. Reaction of soybean accessions and breeding lines to bacterial pustule, summer 1985, AVRDC.

Disease[z] Reaction	No of Entries	%	No. of AGS Lines[y]	%[y]	No. of Accs.	%	No. of Breeding Lines	%
HR	33	32.7	13(8)	31.7(32.0)	20	54.1	0	
HR(-)	12	10.6	10(6)	24.4(24.0)	2	5.4	0	
MR	7	6.7	2(2)	4.9 (8.0)	5	13.5	0	
MS	16	15.4	9(7)	22.0(28.0)	7	18.9	0	
HS	36	34.6	7(2)	17.1 (8.0)	3	8.1	26	100
Total	104		41(25)		37		26	

[z]HR = disease severity similar to or less than that of G 8190. HR(-) = disease severity slightly more than that of G 8190. MR = disease severity similar to that of G 2034 (CNS). MS = disease severity distinctly more than that of G 2034, but less than that of G 38. HS = disease severity similar to or greater than that of G 38.
[y]Numbers in parentheses are for GC lines within AGS lines.

Table 9. AGS lines highly resistant to bacterial pustule.[z]

Glycine Cross (GC) Lines			Others		
AGS No.	Parentage	dr[y]	AGS No	Acc. No. (name)	dr[y]
62	SRF 400 X PI 297550	HR	1 71	G 10140 (BPI #4)	HR
128	SRF 400 x PI 297550	HR	270	G 10468 (PK7394)	HR
136	Essex X TN #4	HR	272	G 10470 (FOSTER)	HR
138	SRF 400 X PI 297550	HR	273	G 10471 (CEP7177)	HR
139	SRF 400 X PI 297550	HR	275	G 10452 (DUO CROP)	HR
152	SRF 400 X PI 297550	HR	266	G 10458 (PK 308)	HR(-)
153	SRF 400 X PI 297550	HR	268	G 10446 (SIATSA 194)	HR(-)
9	Shih-Shih X SRF 400	HR(-)	269	G 10467 (PK 7386)	HR(-)
19	Shih-Shih X SRF 400	HR(-)			
129	Shih-Shih X SRF 400	HR(-)			
141	SRF 400 X PI 297550	HR(-)			
142	SRF 400 X PI 297550	HR(-)			
147	Shih-Shih X SPF 400	HR(-)			

[z]Confirmed in summer 1985. [y]Disease rating.

Ten AGS lines were rated highly resistant (HR-) to this disease. Six of these AGS lines were the result of the crossing program, and the other four lines were accessions selected as AGS lines. All of these six highly resistant AGS lines were also derived from two crosses: Shih-Shih X SRF 400 and SRF 400 X PI 297550. Apparently, SRF 400 was a source of pustule resistance.

The pedigrees of 12 of the 20 accessions rated as highly resistant were identified (Table 10). In all 12 accessions the cultivar CNS was used as a parent and most probably as the source of bacterial pustule resistance. However, their level of resistance was higher than that of G 2034, our accessions listed as CNS. Another two accessions, G 2424 and G 1994 (= SRF 400), were rated as highly resistant to the disease. This result confirms that SFR 400 is a good source of pustule resistance.

All 26 breeding lines with potential rust tolerance were rated as highly susceptible. All of the AGS lines and accessions that were rated HR last year were again rated highly resistant (HR or HR-) this year.

Table 10. Soybean accessions highly resistant to bacterial pustule.[z]

Acc. No.	Cultivar Name	Disease Reaction	Pedigree
G 1994	SRF 400	HR	Rogue in Clemson
G 2025	Hutton	HR	F55-822//Roanoke/CNS-4
G 2035	Bragg	HR	Volstate/Palmetto//S-100/CNS
G 2296	Bossier	HR	S-100 X CNS
G 2424	SRF 400	HR	Rogue in Clemson
G 5087	Cobb	HR	Roanoke//Ogden/CNS///Pelican////Volstate/Palmetto//S-100/CNS
G 5090	Tracy	HR	Dunfield/Haberlandt//Sib of Lee/PI 171449//4 C.371457//S 100/CNS
G 5288	Custer	HR	[((Peking///S-100/CNS//Lincoln/Richland) X (Peking///S 100/CNS//Lincoln/Richland)) XS-100/CNS//Lincoln/Richland///Blackhawk]X (Peking///S-100/CNS//Lincoln/Richland)
G 5425	Scott	HR	S-100/CNS///Mandarin/Manchu//Richland
G 7965	Hill	HR	Dunfield/Haberlandt//S-100/CNS
G 8190	PI 371611	HR	-
G 8339	PI 219656	HR	-
G 8451	PI 165676	HR	-
G 8499	PI 189402	HR	-
G 8598	Bragg	HR	Volstate/Palmetto//S-100/CNS
G 8651	La Green	HR	Unknown
G 8657	Ottotan	HR	From Taiwan via Hawaii
G 8672	Hutton	HR	F55-822//Roanoke/CNS-4
G 8738	Hardee	HR	Roanoke//Ogden/CNS///Improved Pelican
G 9008	Hardee	HR	Roanoke//Ogden/CNS///Improved Pelican
G 4493	PI 171445	HR(-)	-
G 8467	PI 171446	HR(-)	-

[z]Confirmed in summer 1985.

Conclusion

All AGS lines and accessions that were rated HR last year were again rated highly resistant (HR or HR-) again this year.

Effect of Soybean Development on the Infection of Bacterial Pustule

Introduction

Bacterial pustule caused by *Xanthomonas campestris* pv. *glycines*, is one of the most important diseases in Southeast Asia when soybeans are grown during the rainy season. Chemical control for this disease is not yet available, thus, breeding for disease resistance is very important. High resistance to bacterial pustule is found in many soybean cultivars. Field screening for disease resistance is expensive, however, and is frequently affected by adverse environmental and biological factors.

A technique for screening high populations, preferably at the seedling or vegetative stage, is desirable to reduce costs and environmental effects. This study was conducted in summer 1985 to determine the effect of soybean development on the infection efficiency of *X. campestris* pv. *glycines*.

Materials and Methods

Five soybean seeds of Tainung No. 4 (TN#4) which is highly susceptible, were planted in each of three 15-cm clay pots at each planting date. Planting dates were set at one-week intervals, i.e., 4, 11, 18, 25 July, and 1, 8, 15, 22 August. Each pot was thinned to three plants after germination and placed outside the greenhouse. With a backpack sprayer, all plants were inoculated with a cell suspension of the bacterial pustule agent in the late afternoon of 26 August.

The growth stages of the soybean plants were R4, R2, R1, V7, V5, V4, V2, and V1 in the planting dates of 4, 11, 18, 25 July and 1, 8, 15, 22 August, respectively. The first evaluation was made on 3 September one week after inoculation. The evaluation was made on one plant of each pot. Lesion number was counted and leaf area (cm^2) measured for each leaflet. A second evaluation was made on 6 September.

Results and Discussion

The infectivity of *Xanthomonas campestris* pv. *glycines* is significantly affected by the age of susceptible soybean plants at the time of inoculation (Table 11). Lesion densities are low when inoculation was done at the early growth stages (V1-V4), high when it was performed during the reproductive stages (R1-R4), and intermediate when it took place during the vegetable stages just prior to flowering (V5-V7). Full expression of susceptibility occurred only during the reproductive stage. Therefore, inoculation at or after the R1 stage will allow the best differentiation between resistant and susceptible plants.

Table 11. The effect of soybean development on bacterial pustule infection, summer 1985, AVRDC.[z]

Planting Date	GSI (DAP)	Evaluated on 3 Sept.			Evaluated on 6 Sept.		
		lsn/l	la/l (cm^2)	lsn/cm^2	lsn/l	la/l (cm^2)	lsn/cm^2
4 July	R4(53)	339.7	40.12	8.47	413.0	41.49	10.09
11 July	R3(46)	313.3	34.37	9.08	370.6	38.06	9.77
18 July	R1(39)	316.8	38.12	8.40	397.0	40.89	9.82
25 July	V7(32)	215.9	35.38	6.07	347.0	46.39	7.44
1 Aug.	V5(25)	84.2	36.44	2.29	88.9	34.98	2.54
8 Aug.	V4(18)	17.5	24.57	0.72	21.7	25.63	0.85
15 Aug.	V2(11)	6.3	16.96	0.38	13.5	20.44	0.67
22 Aug.	V1(4)	0.0	16.13	0.0	0.0	17.60	0.0
LSD	0.05	95.76	6.34	2.44	96.33	7.46	2.56
	0.01	132.91	8.79	3.39	133.70	10.36	3.55
CV		33.81	11.95	31.47	26.64	12.84	38.36

[z]Data were based on three plants in each planting date. Cultivar: TN#4; GSI: growth stages after inoculation; DAP: days after planting; lsn/l: lesion no. per leaflet; la/l: leaf area per leaflet; lsn/cm^2: lesion no. per cm^2.

The data indicated that it was not possible to conduct a screening test for bacterial pustule on seedlings because of the very low infectivity of *Xanthomonas campestris* pv. *glycines* in a susceptible cultivar during the early vegetative stages. It was also unlikely to do it before the R1 growth stage because of the very rapid transition from a resistant reaction (low lesion density) to a susceptible (high lesion density) prior to flowering of the susceptible plants. Therefore, field screening for pustule resistance is the only practical mass-screening technique.

Conclusion

The infectivity of *Xanthomonas campestris* pv. *glycines* was significantly affected by the age of susceptible soybean plants at the time of inoculation. The data indicated that it was not possible to

develop a resistance screening test for bacterial pustule on seedlings because of the very low infectivity of *Xanthomonas campestris* pv. *glycines* during the early vegetative stages of a susceptible cultivar.

Effect of Early and Late Harvests on Yield, Seed Quality, and Germination of Soybean

Introduction

Previous studies have shown that harvesting soybean during the rainy season results in poor seed quality and germination. It has been reported that pod- and seed-inhabiting fungi such as *Colletotrichum*, *Phomopsis*, and *Cercospora* cause this reduction in seed quality and germination. They constitute a serious problem during warm, wet weather. This research studied the effect of early and late soybean harvests during the rainy and dry seasons with respect to yield, seed quality, and germination percentage.

Materials and Methods

The treatments in the main plots were the harvest dates at different growth stages: R6.8 (pods turning yellow), R7, R8, and one week after R8. Subplot treatments consisted of three cultivars: Taita Kaohsiung No. 5 (TK #5), AGS 129, and AGS 181 (SRE-Z-11A) in the spring season and TK #5, AGS 129, and G 38 (Shih-Shih) in fall. The experiments, arranged in a split-plot design, were planted on 16 March and 21 September in spring and fall in 3 x 5 m plots (2 x 4 m harvested area) at a plant density equivalent to 400,000 plants/ha with three replications. Dithane M-45 (400X dilution) was sprayed at two week intervals until R6 for the control of rust.

After harvest (21 June to 13 July), 400 seeds from each treatment and replication were randomly collected and visually evaluated to assess seed quality (2 August) which was expressed as the percentage of quality seeds (normal seed size without blemishes), diseased seeds, and small or deformed seeds. Another 400 seeds were also randomly collected to evaluate germinability. One hundred seeds of each replicate in each treatment was planted on 21 August in flats with nonsterilized soil. The evaluation of germination was determined on 4 September at the appearance of the first trifoliolate leaf.

Results and Discussion

In both the spring and fall seasons, neither yield nor 100-seed weight within cultivars were significantly affected by early or late harvesting in comparison with those of the normal harvest date at the R8 growth stage, except in AGS 181 (Tables 12 and 13). A significant reduction in 100-seed weight was observed in AGS 181 harvested at the R6.8 growth stage in the spring season (Table 12).

Seed quality was excellent in the fall season; there were no significant differences between treatments or cultivars. In spring, the percentage of visually assessed quality seeds was high; and harvesting date (early or late) did not significantly affect it, except in AGS 181. A significant reduction in quality seeds was observed in AGS 181 harvested one week after the R8 growth stage. This reduction was associated with a high percentage of diseased seeds (Table 12).

Although the percentage of quality seeds was generally high for cultivars in the fall, germination in the spring season ranged from poor to moderately good, depending on cultivar and harvest date; and was apparently not related to the visual assessment of seed quality (Table 12). Apparently, other factors that were not visually assessed, such as physiological factors or the symptomless presence of pathogens, have an important affect on germinability.

The percentage of diseased seeds increased with advancing plant age in all cultivars during the spring season, with the highest percentage on seeds harvested one week after R8. Conversely, the percentage of small seeds decreased with increasing age (Table 12). Consequently, the best time to harvest soybean when harvest coincides with the rainy season would be during the R7 growth stage. This minimizes diseased and small seeds and, therefore, maximizes quality seeds.

Harvest date had no effect on the germinability of soybean seeds during the fall season (Table 13), but considerably affected it when the seeds were harvested in spring (rainy season). The highest

germination in spring was below the poorest germination in fall (Tables 12 and 13). In spring, germinability varied considerably among cultivars, with TK #5 having the highest germination (80-87%) in all harvest dates; AGS 129, the lowest (29-58%); and AGS 181, the highest variation in germination (20-80%) among harvest dates (Table 12).

The highest germination among cultivars in spring occurred when the seeds were harvested at the R7 and R8 growth stages. Delayed harvest (at R8 + 1 wk) significantly reduced germinability in AGS 129 and AGS 181; this was most probably due to weathering. Early harvest at R6.8 also significantly reduced germinability in AGS 181; this was probably because the seeds were not yet mature, since the 100 seed weight of this cultivar was also significantly reduced (Table 12).

Table 12. The effect of early and late harvests on yield and seed quality during the rainy spring season, AVRDC[z].

Variety	Growth Stage at Harvest	Days to Harvest	Yield (kg/ha)	100 Seed Wt. (g)	Germination[y] (%)	Seed Quality (%) good	diseased	small
TK #5	R6.8	97	2793.6	15.33	86.6(69.0)	86.00	0.67	13.33
	R7	103	2598.4	17.23	82.2(65.2)	93.33	1.00	5.67
	R8	108.7	3038.6	16.37	82.2(65.2)	90.33	6.00	3.67
	R8 + 1 wk	115	3046.2	16.91	80.0(64.8)	82.33	16.33	1.33
AGS 129	R6.8	101	3497.6	17.37	46.6(42.7)	90.67	1.67	7.67
	R7	105	3573.1	17.54	57.6(49.7)	92.00	3.00	5.00
	R8	112	3794.1	18.74	57.8(49.6)	90.33	6.00	3.67
	R8 + 1 wk	112	3756.9	18.70	28.8(31.9)	88.67	11.33	0
AGS 181	R6.8	77	2130.9	15.21	20.0(26.0)	92.00	0.67	7.33
	R7	84	2465.8	17.33	75.6(61.0)	97.33	1.33	1.33
	R8	89.3	2575.9	17.94	80.0(63.7)	95.67	4.33	0
	R8 + 1 wk	97	2473.3	17.53	35.6(36.4)	69.67	30.33	0
LSD[x]	5%	0.81	NS	1.65	(17.1)	9.60	8.09	5.41
CV		0.47		5.58	(18.06)	6.23	67.85	76.47

[z]Planted 16 March 1984; design: split plot, replications: 3. [y]From each of three replications in each treatment of each variety, 100 seeds were planted and evaluated. Dates in parentheses are arcsine transformation for analysis and evaluation. [x]LSD for harvest dates within cultivars.

Table 13. The effect of early and late harvests on yield and seed germination in fall, AVRDC.

Variety[z]	Growth Stage at Harvest	Days to Harvest	Yield (kg/ha)	100-Seed Wt (g)	Germination (%)
TK #5	R6.8	91	2254.8	16.3	99.0
	R7	96	2406.3	16.5	99.50
	R8	98	2338.6	16.5	99.25
	1 wk after R8	105	2486.8	17.0	99.50
AGS 129	R6.8	101	2351.6	16.1	98.75
	R7	104	2517.5	16.7	96.50
	R8	109	2441.9	17.1	97.25
	1 wk after R8	116	2526.4	17.5	98.00
G 38	R6.8	90	2422.8	17.9	98.50
	R7	94	2474.7	17.0	99.50
	R8	97	2358.9	17.1	98.00
	1 wk after R8	104	2475.6	18.0	99.25
LSD 5%[y]			183.2	NS	NS
CV			4.41		

[z]Planted: 21 September 1984. [y]LSD for differences between subplot treatments, for the same main plot treatments. NS = no significant difference.

Conclusion

Seeds harvested in the fall (dry) season were not affected by harvest date for the parameters evaluated. Significant variations occurred when seeds were harvested during the rainy season. Highest germination among cultivars occurred when the seeds were harvested at the R7 and R8 growth stages. Germinability also varied considerably among cultivars, with TK #5 having the highest germination (80-87%) in all harvest dates. The best time to harvest soybean in the rainy season would be during the R7 growth stage. This minimizes the percentage of diseased and small seeds and, therefore, maximizes the percentage of quality seeds and germinability.

Effect of Seed Size and Storage Environment on Soybean Germination

Introduction

Field observation in previous experiments indicates that seed size is inversely correlated with germinability, therefore, the larger the seed size, the poorer the germination. Also, it was observed that soybean seed lose germinability very quickly during storage at room temperature in the tropics. This study was conducted to understand the relationship between seed size, storage environment, and soybean germinability.

Materials and Methods

Three cultivars with different seed sizes were used: PI 459025 (large seeds), AGS 129 (intermediate seed size), and AGS 66 (small seeds). Their seeds were harvested during the fall 1984 season (18 December 1984 to 7 January 1985) and collected in a random manner. The seeds of each cultivar were put into two plastic jars with a screwed lid. One jar of each cultivar was placed in a cold room (4 ± 1 C) and the other in the headhouse at room temperature, which included air conditioning during normal working hours when temperature was above 28 C.

Germination tests were initiated on 1 February 1985 and continued at two month intervals until the end of the year. For each germination test, 400 seeds from each cultivar and storage condition were randomly collected and planted in plastic flats containing unsterilized potting soil (soil, compost, rice hull, and sand at a 5:3:1:1 ratio). Each replication consisted of 100 seeds of each cultivar planted in a single flat, watered, and placed outside the greenhouse. Germination percentage was evaluated when the first trifoliolate leaf of most plants in each cultivar was fully expanded.

Results and Discussion

There was no indication that seed size was related to germinability under these storage conditions. In general, the poorest seed germination after storage was observed on AGS 129, the cultivar with the intermediate seed size (Table 14).

Table 14. Effect of seed size and storage environment on the germination of soybean, AVRDC 1985.[z]

Cultivar	Germination Percentage[y]											
	1 Feb.		1 April		31 May		1 Aug.		1 Oct		2 Dec.	
	cr	hh	cr	hh	cr	hh	cr	hh	cr	hh	cr	hh
PI 459025	98.0	97.8	97.3	94.5	53.0	50.5	92.0	86.3	79.3	41.8	94.8	76.8
AGS 129	99.3	98.3	95.5	96.8	21.0	26.5	82.3	80.8	59.8	14.5	97.5	68.5
AGS 66	98.0	98.0	97.8	96.5	41.0	37.8	91.8	84.5	77.8	50.8	98.0	70.8

[z]Storage temperatures: cold room 4 ± 1 C, headhouse room temperature; seeds were collected from the 1984 fall planting. [y]The dates refer to planting days. cr cold room, hh headhouse.

The germination of seeds stored in the cold room remained very high even after nearly one year of storage (94-97%). Even for the seeds stored at room temperature, it remained moderately high (81-86%) after seven months of storage. This result was unexpected, especially in the large-seeded cultivar (PI 459025), and this probably resulted from the use of plastic storage containers with a tight-fitting lid (Table 14).

Other factors, besides storage container and temperature, affected seed germinability in this experiment. Heavy rainfall during planting on 31 May (114 mm) apparently reduced germinability in this test in comparison with either of the tests two months before or after. The factors involved in the unaccountably low germinability in the October test have not yet been determined.

Conclusion

Three cultivars with a range of seed sizes were stored in both a cold room and a headhouse (office/laboratory) over a period of one year. There was no indication that seed size was related to germinability under these storage conditions. In general, poorest seed germinability after storage was associated with the cultivar having an intermediate seed size. The germinability of seeds stored in the cold room remained very high even after nearly one year of storage (94-97%). Even for the seeds stored at room temperature, germinability remained moderately high (81-86%) after seven months of storage.

Effect of Dithane M-45 and Benlate on Soybean Seed Quality

Introduction

Loss of seed germinability after harvest during the rainy season is a major constraint in Southeast Asia. The influence of soybean rust, an important disease in this region, on postharvest seed germinability is not completely understood. The objective of this study is to determine whether reduced postharvest germinability of soybean seeds harvested during the rainy season is due to rust or other factors, and to determine the effect of preharvest fungicides on postharvest seed germination.

Materials and Methods

A split-plot design with four replications was used. Treatments in the main plots were two cultivars with different seed sizes (AGS 129 with intermediate size seed and PI 459025 with large seeds); and in the subplots were fungicide spray applications as follows: a) Dithane M-45, 80% w.p. at 400 X dilution; b) benomyl, 50% w.p. at 1000 X dilution; c) Dithane M-45 at 400 X + benomyl at 1000 X; and d) check without fungicide. Fungicide application was initiated at the R1 growth stage and continued at two week intervals.

Data on days to R8, plant height, pod number per plant, branch number per plant, yield, and 100-seed weight were collected before harvest. After harvest and threshing, data were collected on the percentages of visually assessed diseased and healthy seeds based on 400-seed samples per plot.

Two germination tests were conducted: the first was planted on 1 August, approximately two weeks after the last cultivar was harvested, and the second was planted on 26 August. For each germination test, 400 seeds from each cultivar and fungicide treatment were randomly collected and planted in plastic flats containing unsterilized potting soil (soil, compost, rice hull, and sand at a 5:3:1:1 ratio). A replication consisted of 100 seeds of each cultivar planted in a single flat. After planting the seeds, the flats were watered and placed outside the greenhouse. Germination percentage was evaluated when the first trifoliolate leaf of most plants in each cultivar were fully expanded.

Results and Discussion

Rust was effectively controlled in the plots that received Dithane M-45, either alone or in combination with benomyl (Table15). The rust was only partially controlled when benomyl was used

alone. In all of the fungicide treatments, days to maturity and 100-seed weight were significantly increased because of partial or nearly complete control of the rust. However, increase in yield and pod number per plant due to fungicide application was only significant in cultivar AGS 129; indicating that, although some yield components of PI 459025 were significantly affected by rust, yield and pod number per plant were not (Table 15). The other experiments showed that PI 459025 had a higher level of tolerance to rust than AGS 129.

The percentage of visually assessed healthy seeds was not significantly increased by any of the fungicide treatments in either cultivar. The percentage of healthy seeds in all treatments was high (86-99%) and was significantly higher for AGS 129 than for PI 459025, in any treatment (Table 15).

Germination of the seeds in both tests was low, considerably lower in the second test (0-13%) than in the first (4-72%). The germination of AGS 129 was significantly higher than that of PI 459025. None of the fungicide treatments improved the germinability of either cultivar, except of AGS 129 in the Dithane M-45 + benomyl treatment in the second germination test (Table 15). Apparently, under the conditions of this experiment, rust did not affect seed germinability, nor did the fungicides reduce the other constraints that caused poor seed germination.

Conclusion

Dithane, either alone or in combination with benomyl nearly completely controlled rust; however, neither fungicide alone nor its combinations improved germination. Apparently, under the conditions of this experiment, rust did not affect seed germinability, nor did the fungicides reduce the other constraints that caused poor seed germination.

Population Dynamics of Mycorrhizal Fungi in the Rice-Rice-Soybean Cropping System

Introduction

A previous study indicated that the spore population of vesicular-arbuscular (VA) mycorrhizal fungi in the rice-rice-soybean cropping system is relatively constant throughout the year. The only exception noted was that it was very low at the sampling date two to three weeks after the sowing of soybean. However, the conclusions of this survey was based on only four samples during a one-year period.

Another survey indicated that mycorrhizal species occurred in agricultural soils with a wide range of phosphorus levels from low (15 ppm) to very high (285 ppm). However, sufficient data were not available to correlate the spore populations of mycorrhizal fungi with phosphorus levels. The purpose of this study was to further understand the dynamics of the spore population of mycorrhizal fungi in the rice-rice-soybean cropping system and to determine the relationship between spore populations to phosphorus levels.

Materials and Methods

Monthly surveys (11) were conducted in Pingtung County from November 1984 to October 1985 in six fields with a rice-rice-soybean cropping system. One field was selected in each of five villages (Nei Pu, Chour Jou, Wan Luen, Chu Ru, and Lu Kang) and one in the Kaohsiung District Agricultural Improvement Station (DAIS).

In each field at each survey date, 30 soil samples were randomly collected from the upper 18 cm layer of the soil. The soil samples from each field and survey were combined and thoroughly mixed, and three to five aliquots of 100 g each were withdrawn for examination. Spores of mycorrhizal fungi and crop roots were extracted from the soil by wet sieving and decanting. The crop roots were stained in trypan blue lactophenol. Both spores and roots were examined microscopically. The soil samples from each field and survey date were analyzed for P_2O_5 concentration by Olsen's method.

Table 15. The effect of Dithane M-45 and benomyl on the yield components, seed quality, and germination of two cultivars, spring 1985.[z]

Treat-ment[y]	Days to R8		Pod No./ Plt[x]		Yield (kg/ha)		100-Seed Wt (g)		Dis. Seeds[w] (%)		Germin., 12 Aug.[w] (%)		Germin., 9 Sept.[w] (%)	
	AGS129	459025	AGS129	459025	AGS129	459025	AGS129	459025	AGS129	459025	AGS129	459025	AGS129	459025
A	106.5	122.3	25.8	16.0	3181	2100	15.8	30.8	2.88	12.13	61.63	8.63	10.50	0.13
B	101.5	119.0	26.6	13.3	2618	2110	13.6	30.2	0.56	10.00	50.38	21.44	7.56	0.25
C	106.5	127.0	26.2	16.7	3106	1975	16.1	28.1	0.82	9.38	71.50	3.63	13.32	0.00
D	97.0	109.8	20.8	14.6	1880	1855	11.1	26.0	1.38	5.13	65.31	22.06	6.06	0.38
LSD 0.05														
within column	2.90		5.08		512.0		1.99		5.28		16.48		5.62	
between columns	3.25		4.31		448.2		2.41		5.27		14.31		5.57	

[z]Planted: 6 March 1985. Replications: 4. [y]Fungicide spraying was initiated at the R1 stage: A = 80% w.p. Dithane M-45 at 400X; B = 50% w.p. benomyl at 1000X; C = Dithane M-45 + benomyl; D = control. [x]Mean of 50 plants in each plot. [w]Dis. = diseased. Germin. = germination. All data were evaluated from 400 seeds in each plot.

Results and Discussion

Although there were differences in mean spore concentration among the locations (Table 16), the highest mean spore concentration was considerably lower than those found in the previous survey. The differences in spore populations between the two surveys may be the result of many factors.

A few of these were probably the different field sites and sampling methods, different agronomic practices (including a new chemical used for snail control which has fungicidal properties), and the presence of very high concentrations of nematodes in the present survey.

Five VA mycorrhizal species, *Glomus mosseae*, *G. etunicatus*, *G. clarus*, *G. macrocarpus* v. *macrocarpus*, and *Acaulospora* spp. were the predominant mycorrhizal fungi in all locations and surveys. At four locations (DAIS, Nei Pu, Chiu Ru, and Lii Kang), *G. mosseae* was the predominant species. At the other two, no species was predominant, except at specific sampling dates (Table 16 and Figs. 2 to 4).

Table 16. Mean values of mycorrhizal spore populations (spore no./100 g soil) of five predominant species, soil ph, and phosphorus concentration at the six survey sites.

Location	Mycorrhizal Species					Total	pH Value	P_2O_5 Concentration
	G. mosseae	*G. etunicatus*	*G. clarus*	GMM[z]	*Acaulospora*			
DAIS	43.52	3.87	0.73	2.46	1.20	73.88	5.90	109.47
Nei-Pu	14.05	4.44	0.82	0.57	1.29	44.20	6.20	73.54
Chour-Jou	4.19	3.42	3.76	4.28	1.12	29.92	5.70	60.23
Wan-Luen	1.98	3.38	3.55	3.01	2.65	24.52	5.30	57.63
Chiu-Ru	24.69	7.43	1.94	3.40	0.93	53.75	5.90	61.39
Lii-Kang	9.32	4.03	1.38	0.56	0.93	30.15	6.30	210.95

[z]GMM *Glomus macrocarpus* var. *macrocarpus*

The mean pH levels (5.3 to 6.3) indicated that all of the soils were slightly to moderately acid. The mean phosphorus (57 to 211 ppm) concentrations ranged from adequate to high. However, there seemed no relationship between the total spore population at the six locations and the location's mean phosphorus concentration. The Lii Kang site which had the highest phosphorus concentration had one of the lowest spore populations. The second highest phosphorus concentration and the highest spore population was found at the DAIS site. The site (Wan Luen) which has the lowest spore population also had the lowest phosphorus concentration (Table 16).

Spore populations and phosphorus concentrations at the different sampling dates also did not seem to be correlated (Figs. 5 to 7). Apparently, under field conditions, other factors can negate the inverse correlation between these two variables.

In the area of this survey, the first rice crop was planted in January and harvested during the second or third week of May; the second crop was planted in early June and harvested in late September or early October. The soybean crop was then planted shortly after the second rice crop was harvested. At two sites, Lii Kang and Wan Luen, spore populations remained constant throughout the year.

At the other sites, one or two peaks in spore populations occurred which were associated with either the first or second rice crops or with both rice crops. This would indicate the presence of mycorrhizal activity in the rice crop. There also was a decrease in spore population between the end of the first rice crop and the beginning of the second rice crop (Figs. 5 to 7).

The highest spore populations were associated with the rice crop and not with the soybean crop as was shown in the previous survey. It appears that this is a result of a recent change in the management of the soybean crop. In all six survey locations phosphorus increased between the end of the second rice crop and the planting of the soybean crop, indicating phosphorus fertilization which previously was not a normal practice (Fig. 3). The phosphorus concentration during the soybean crop may have been sufficiently high to inhibit mycorrhizal associations.

Conclusion

Phosphorus concentrations did not seem to be correlated with spore populations of mycorrhizal fungi under field conditions. Peak spore populations at most locations occurred during one or both of the rice crops, indicating mycorrhizal activity in the rice crop.

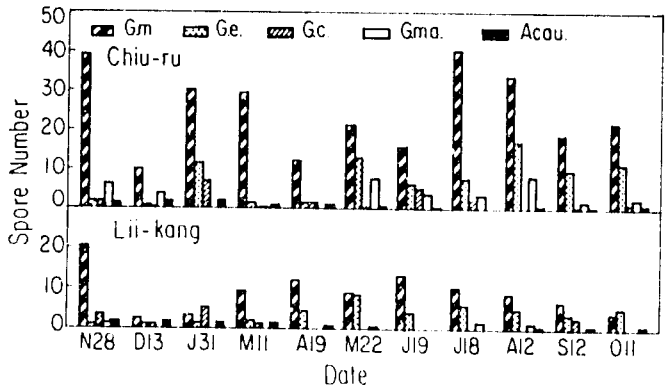

Fig. 2.
Spore populations of five predominant VA mycorrhizal fungi during a one-year survey in Chiu-Ru and Lii-Kang villages (G.m. = *Glomus mosseae*, G.e. = *G. etunicatus*, G.c. = *G. clarus*, G.ma. = *G. macrocarpus* var.*macrocarpus*, and Acau. = *Acaulospora* ssp.).

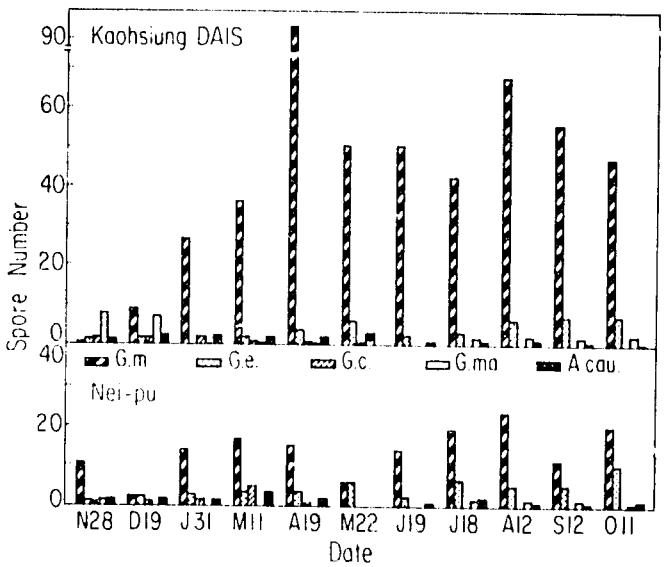

Fig. 3.
Spore populations of five predominant VA mycorrhizal fungi during a one-year survey in Nei-Pu village and Kaohsiung DAIS (G.m. = *Glomus mosseae*, G.e. = *G. etunicatus*, G.c. = *G. clarus*, G.ma. = *G. macrocarpus* var. *macrocarpus*, and Acau. = *Acaulospora* ssp.).

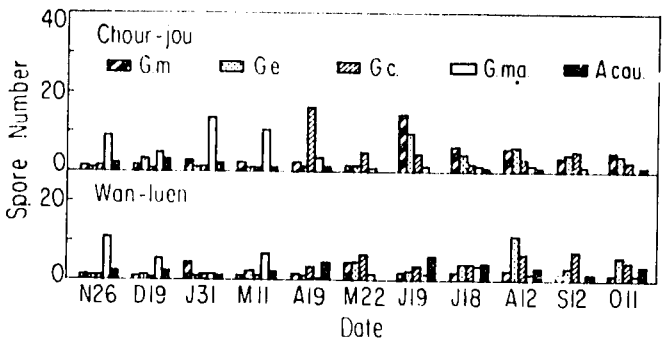

Fig. 4.
Spore populations of five predominant VA mycorrhizal fungi during a one-year survey in Chour-Jou and Wan-Luen villages (G.m. = *Glomus mosseae*, G.e. = *G. etunicatus*, G.c. = *G. clarus*, G.ma. = *G. macrocarpus* var. *macrocarpus*, and Acau. = *Acaulospora* spp.).

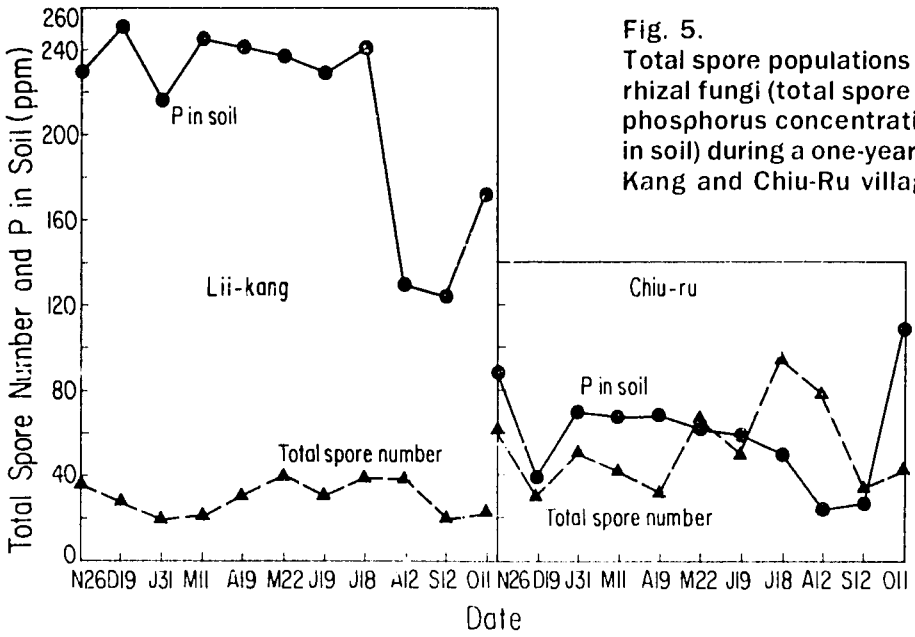

Fig. 5.
Total spore populations of VA mycorrhizal fungi (total spore numb :r) and phosphorus concentration in ppm (P in soil) during a one-year survey in Lii-Kang and Chiu-Ru villages.

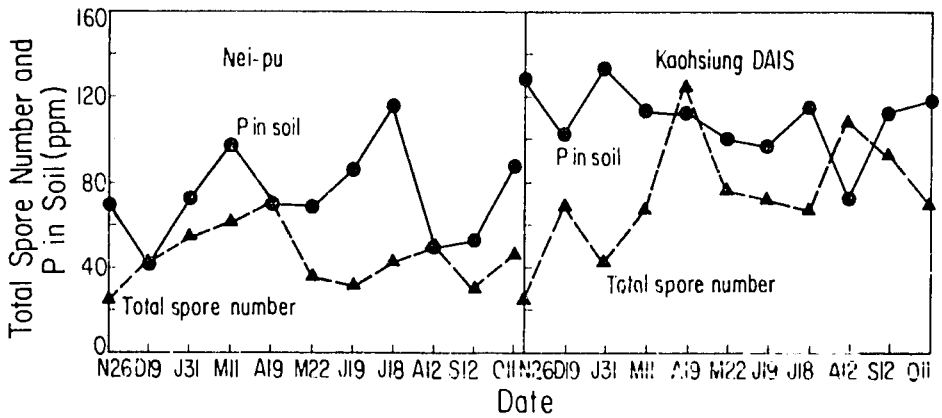

Fig. 6. Total spore populations of VA mycorrhizal fungi (total spore number) and phosphorus concentration in ppm (P in soil) during a one-year survey in Nei-Pu village and Kaohsiung DAIS.

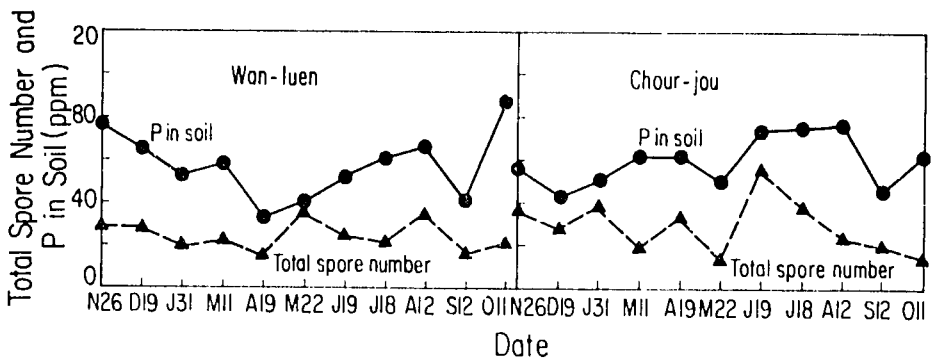

Fig. 7. Total spore populations of VA mycorrhizal fungi (total spore number) and phosphorus concentration in ppm (P in soil) during a one-year survey in Wan-Luen and Chour-Jou villages.

Strains of Soybean Mosaic Virus

Introduction

Most SMV (soybean mosaic virus) isolates recovered from previous surveys were SMV strain G1. In last year's survey of the soybean production areas in Taiwan, SMV strain G3 was detected, based on the 1979 Cho and Goodman classification scheme.[1] Several new SMV isolates have been recovered this year from soybean and were strain-typed.

Materials and Methods

One hundred and fifty-two leaf samples were collected from the Hualien, Pingtung, and Taichung soybean production areas. They were tested for SMV by ELISA. Those showing a positive reaction were inoculated to *Phaseolus vulgaris* cv. Toperop. After three successive single, local-lesion transfers, *Glycine max* cv. TN 4 was inoculated and served as the systemic host.

Strain differentiation was done according to the revised method of Cho and Goodman.[2] Fifteen to twenty plants of the seven differential soybean cultivars were inoculated. Symptomless plants were tested by ELISA to detect latent infection.

Results and Discussion

Nine of the 152 leaf samples collected were found to be positive for SMV in the ELISA test. So far, three of these were strain-typed. One isolate (S-685) was found to be SMV strain G3. Isolates S-368 and S-694 were identified as SMV-G5 and G1, respectively. Both SMV-G1 and G3 have been isolated previously but strain G5, one of the necrotic strains has not been found before. All three strains are now actively used in our SMV resistance-screening program.

The strain, identified last year as G3 by Cho and Goodman's original scheme (which was based on a mixture of strains) is now being tested by the new scheme. We believe, however, that it does not constitute a mixture, because it was obtained after three successive local lesions on *P. vulgaris* cv. Toperop. It may be a new strain. Recently there have been reports of several strains from the U.S.A. which also do not fall into the seven SMV strain categories proposed by Cho and Goodman.

Since resistance to SMV is strain specific, and several genes for resistance are known to occur, the use of as many naturally occurring strains as possible will improve the efficiency of the AVRDC SMV-resistance-breeding program, which is aimed at developing lines with multiple genes for SMV resistance.

The search for other strains is continuing.

Conclusion

So far only SMV strains G1, G3, and G5 have been identified. All three strains are now actively used in our SMV resistance-screening program. Several isolates of SMV have also been recovered which do not fit into the seven SMV strain categories proposed by Cho and Goodman. They may represent new strains.

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[1] Cho, E. K. and R. M. Goodman. 1979. Strains of soybean mosaic virus. Classification based on virulence in resistant soybean cultivars. Phytopathology 69:467-470.

[2] Cho, E. K. and R. M. Goodman. 1982. Evaluation of resistance in soybeans to soybean mosaic virus strains. Crop Science 22:1133-1136.

Screening for Resistance to Three SMV Strains and Three Isolates of the Unknown Soybean Virus

Introduction

Resistance to SMV is reported to be strain-specific and several genes for resistance have been identified. Previously, screening for resistance to SMV could only be done with SMV-G1, the only available strain. However, recently we detected two more strains, G3 and G5 which can now be used for screening. In the past, several AGS lines have been identified with resistance to SMV-G1, but it was not known if this resistance was also effective against the other SMV strains or for the unknown soybean virus.

Materials and Methods

Sixty-one AGS lines (AGS 230 to AGS 290) were screened for the first time for resistance to SMV-G1. All AGS lines with immunity to SMV-G1 were then also screened with SMV-G3, G5, and G5H and with the unknown virus isolates PN, PM, and 74. All of the available parents and 26 *Glycine max* lines with reported resistance to SMV G1 or other SMV strains were also screened with the above-mentioned viruses and strains. SMV G5H is a new strain of SMV recently detected in Korea. Screening for this strain was done by our Korean cooperators. Forty plants of each line were tested by the method described in the 1984 Progress Report.[1]

Results and Discussion

Nine of the newly screened AGS lines were found to be immune to SMV-G1: AGS 231, 239, 240, 252, 255, 257, 261, 263, and 264. Two lines, AGS 244 and AGS 281, had a low infection rate (4% infected plants) in response to the inoculation of SMV-G1.

The reactions of SMV G1 resistant AGS lines to other available SMV strains and the unknown virus are shown in Table 17; the reaction of their parents, in Table 18. Twenty-four, or 8% of the 290 advanced *Glycine* selections carry immunity to SMV G1. All lines with immunity to SMV-G1 were also found immune to SMV G3.

However, the gene(s) that conferred immunity to G1 and G3 in these lines did not necessarily confer resistance to strain G5. With the exception of AGS 214, 218, and 239, all AGS lines which were immune to SMV-G1 and G3 were susceptible to SMV G5. However, almost all the G1- and G3-immune lines were also immune to the unknown virus isolates PN, PM, and 74. So far, we do not know if the gene that confers immunity to G1 and G3 is also responsible for immunity to the unknown virus.

AGS lines 214 and 218 were immune to SMVG1, G3, and G5 and to the unknown virus as well. These lines may have either an additional gene responsible for the additional resistance to G5, or may have one gene that differs from that of the other lines, in giving immunity to all three SMV strains and to the unknown virus.

AGS 239 was found to be immune to the three SMV strains only, but not to the unknown virus. This line either lacks the additional gene which gives resistance to the unknown virus, or a different gene is giving it resistance to the three SMV strains, but not to the unknown virus.

Several sources of immunity to SMV G1 and SMV G3 were identified among the parental lines G 38 (*G. max*, cv. Shih-Shih), G 2042 (*G. max*, cv. Tainung No. 3), G 4713, and G 4919. However, only the last two were pure with respect to immunity to G1 and G3; the other lines were segregating and contained susceptible individuals among the plant populations, indicating that they are probably not pure lines. Most AGS lines appeared to derive their immunity to G1, G3, and to the unknown virus from *G. max* TN 3 or *G. max* Shih-Shih.

[1]AVRDC. 1984 Progress Report. Shanhua, Tainan, Taiwan.

Table 17. Reactions of selected AGS lines to SMV-G1, G3, G5, G5H, and to the unknown virus isolates PN, PM, and 74.[z]

AGS No.	Pedigree	SMV G1[y]	G3	G5[x]	G5H	Unknown Virus PN	PM	74
9	Shih Shih x SRF 400	I	I	S		I	I	I
19	Shih Shih x SRF 400	I	I	S		I	I	I
103	G 7026 x AGS 2	I	I	S		I	I	I
112	Shih Shih x SRF 400	I/S(11%)	I	S	S	I	I	I
115	TN 3 x PI 31406	I/S(13%)	I	S	S	I	I	I
129	Shih Shih x SRF 400	I	I	S		I	I	I
147	Shih Shih x SRF 400	I	I	S		I	I	I
174	Shih Shih x TN-3	I	I	S	S	I	I	I
185	Houjaku x G 6713	I	I	S	S	I	I	I
209	TN 3 x Funmar	I	I	S	S	I	I	I
214	TN 3 x SJ 2	I/S(2%)	I	I	S	I	I	I
216	KS 739 x Akijoshi	I/S(2%)	I	S		S	S	S
218	TN 3 x SJ 2	I	I	I		I	I	I
231	Tokachinagaha x AGS 2	I	I	S		I/S(2%)	NT	NT
239	80834-2 x 86109 Ped	I	I	I		S	NT	NT
240	AGS 2 x PI 230970	I	I	S		I/S(8%)	NT	NT
244	AGS 2 x PI 230970	I/S(4%)	I	S		I/S(25%)	NT	NT
252	Shih Shih x TN 4	I	I	S		I/S(8%)	NT	NT
255	Shinsei x PI 227224	I	I	S		I/S(8%)	NT	NT
257	Shih Shih x TN 4	I	I	S		I/S(17%)	NT	NT
261	TN 3 x Funmar	I	I	S		I	NT	NT
263	Shih Shih x AGS 2	I	I	S		I/S(8%)	NT	NT
264	TN 3 x SJ 2	I	I	S		I	NT	NT
281	TN 3 x Q 68	I/S(4%)	I	S		I/S(13%)	NT	NT

[z]I = immune; S = susceptible, with mosaic symptoms; I/S = segregating for immunity and susceptibility. [y]Numbers in parentheses indicate the percentage of susceptible plants. [x]All susceptible reactions with G5 are of the systemic necrosis type; = necrotic local lesions, but no systemic infection, on the inoculated leaves.

Table 18. Reactions of 20 parents of AGS breeding lines to three SMV strains and to the unknown virus isolates PN, PM, and 74.[z]

Acc. No.	Cultivar Name	SMV[y] SMV-1	SMV-3	SMV-5[x]	Unknown Virus PN, PM, 74
7	TN 3	S	S	S	S
33	TN 3	S	S	S	S
38	Shih-Shih	I/S(5%)	I	S(N/N)	I
605	Funmar	S	S	S	S
1385	(PI 80834-2)	I/S(72%)	I/S(10%)	S	S
2019	TN 3	S	S	S	S
2042	TN 3	I/S(22%)	I/S(13%)	S(N/N,M)	I/S(N)
2120	AGS 2	S	S	S	S
2424	SRF 400	S	S	S	S
2502	Shinsei	S	S	S	S
2506	Tokachinagaha	S	S	S	S
2573	SJ 2	S	S	S	S
4713	AGS 185 (Houjaku)	I	I	S	I
4919	Akitoshi	I	I	S(N/N,M)	S(N/N,M)
7026	PI 189935	S	S	S	S
8252	86109-Ped	R	S	S	S
8582	PI 227224	S	S	S	S

[z]I = immune; S = susceptible, with mosaic symptoms; I/S = segregating for immunity and susceptibility. [y]Numbers in parentheses indicate the percentage of susceptible plants. [x]All susceptible reactions with G5 are of the systemic necrosis type.

The source of immunity to G1 and G4 in three AGS lines (AGS 103, AGS 231, AGS 264) was not known, since all of their parents were found susceptible to G1 and G3. Similarly, among the parents of AGS 214, 218, and 239, the source of immunity to G5 could not be identified because all parents of these three lines were susceptible to G5.

The reactions of 26 *G. max* lines with reported resistance to SMV-G1 or other SMV strains are shown in Table 19. Among these were seven with immunity to SMV G5 (Accs.1356, 2034, 2040, and 8044, OX615, PI 483084 A, PI 483084 B), five of which were immune to both G5 and the unknown virus (Accs.1356, and 2034, OX615, PI 483084 A, PI 483084 B). These five lines were recommended to the breeders for use in the virus resistance breeding program.

Since immunity to G1, G3, and to the unknown virus is already present in 8% of the AGS lines, future resistance breeding should focus on the incorporation of resistance to G5, and as they become available, also to other strains of SMV.

Table 19. Reactions of *G. max* lines reported to be resistant or immune to SMV-G1, to other available SMV strains, and to the PN isolate of the unknown virus.[z]

G. max[y]	G 1	G 3	G 5	Unknown Virus (PN)
G 5	I	I	S(N)	I
G 260	I	I	S(N,M)	I
G 270	I	I	S(N)	I
G 288	I	I	S(N,M)	I
G 311	I	NT	S	I
G 358	I	I	I/S(40%N)	I
G 452	I	I	S(N)	I
G 453	I	I	S(N)	I
G 519	I	I	S(N)	I
G 1096	I	NT	S(N)	I
G 1356	I	NT	I	I
G 1601	I	I	I/S(37%N)	I
G 2021	I	NT	NT	S
G 2034	I	I	I	I
G 2040	I	NT	I	S(N,M)
G 2261 (Tainung 15)	I	I/S(2%M)	I/S(38%N)	I
G 8044	I	NT	I	S(N,M)
G 8889	I	NT	NT	S(N)
VG-14 (PI 360835)	I	I	S(N)	I
VG 15 (PI 96983)	I	NT	NT	S(N)
VG 23 (PI 96983)	I/S(7%M)	I	S	S(N,M)
VG-13 (PI 324068)	I	NT	NT	S(N)
VG 22 (OX 615)	I	NT	I	I
VG 24 (PI 483084 A)	I	I	I	I
VG 25 (PI 483084 B)	I	I	I	I
Gun Tsuru (610157)	I	NT	NT	I

[z] I = immune, S = susceptible, with mosaic symptoms unless otherwise stated, I/S = segregating for immunity and susceptibility, N = systemic necrosis, NL = necrotic local lesions on the inoculated leaves only, no systemic infection. Numbers in parenthesis indicate the percentage of susceptible plants. [y] G = AVRDC *Glycine max* accessions, VG = accession no. of virus indicator plant collection (virology).

Conclusion

Twenty-four of the 290 AGS lines were found to be immune to G1 and G3 and to the unknown virus. Only three of these lines were also resistant to SMV-G5. These lines either have an additional gene for resistance, besides the one(s) that confers resistance to SMV G1, G3, and to the unknown virus, or a different mechanism conferring resistance to all three strains and the unknown virus.

The source(s) of resistance to G1, G3, and the unknown virus, but not to SMV G5, were identified among the AGS parents. Among the AVRDC accessions, several lines were identified with immunity to G5 and/or G1 and G3 and/or the unknown virus. Two lines had immunity to G1, G3, G5, and the unknown virus.

Further Characterization of Soybean Virus Isolates, PN, PM, and 74

Introduction

During a survey of the major soybean-growing areas in Taiwan during 1983-84, a virus was found which was not previously reported here. The virus, a poty virus with a particle length between 733 and 797 nm, is transmitted by aphids in a nonpersistent manner. Its host range is largely confined to members of the legume family, including economically important crops such as soybean, French bean, cowpea, and yard-long bean. *Nicotiana benthamiana*, *N. clevelandii*, and *Chenopodium quinoa* are the only nonleguminous hosts infected systemically.

On the basis of these findings it was not possible to identify this virus. Serological tests indicated that it was closely related to blackeye cowpea mosaic virus (BlCMV), adzukibean mosaic virus (AzMV), and the NY15 strain of BCMV (BCMV-NY15). To exactly establish the identity of this virus and compare it with BlCMV and AzMV, it was, therefore, necessary to conduct EM cytological studies to determine the stability in sap and the molecular weights of the protein coats. Additional hosts, including those of BlCMV and AzMV, were also tested.

Materials and Methods

Cytological observations were performed on ultrathin sections of leaf tissues of systemically infected *N. benthamiana* embedded in Epon (Jones, et al. 1980).* Thermal inactivation points (TIP), longevity *in vitro* (LIV) and dilution end point (DEP) were determined by the standard methods, using *Chenopodium amaranticolor* as a local lesion-assay plant.

For the determination of the molecular weights of virus coat proteins, purified virus preparations were mixed at a ratio of 4:1 with a solution containing 25 mM Tris-HCl (pH 6.8), 10% (w/v) SDS, 50% (v/v) glycerol, 0.005% bromophenol blue, and 25% (v/v) mercaptoethanol. After a 3-min heating at 100°C, the preparations were electrophoresed in a vertical slab gel using a 4% stacking gel and a 12% separating gel.

The buffers described by Laemmli and Favre (1973) and the low molecular weight calibration kit (14,000 to 94,000 d) were used.** Gels were stained in 6.5% (v/v) acetic acid, 18% (v/v) methanol, 6% (w/v) trichloroacetic acid, and 0.05% (w/v) Coomassie blue for 1 hr and destained for two days in several changes of 6.5% (v/v) acetic acid and 18% (v/v) methanol.

Additional host range studies were carried out by the method described in the 1984 Progress Report.*** Symptomless plants were tested by ELISA.

Results and Discussion

The comparative host range of BlCMV, AzMV, and of isolates PN, PM, and 74 is shown in Table 20. The three unknown soybean isolates infected many more hosts than either BlCMV and AzMV. On the basis of host range, therefore, no conclusion can be drawn on the relationship of the unknown virus with BlCMV and AzMV.

TIP, LIV and DEP values are shown in Table 21. They are almost identical for the three virus isolates PN, PM, and 74. The TIP and DEP were also very similar to the reported values of BCMV, AzMV, BlCMV, and SMV (soybean mosaic virus). However, LIV values of PN, PM, and 74 were much higher than those of the other soybean viruses listed. Since the LIV values are known to depend on the host, the original concentration of the virus in the sap, and the environmental conditions, we will compare LIV of our isolates with BCMV, AzMV, and BlCMV under identical conditions to establish whether they differ or not.

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*Jones, R. A. C., R. Koenig, and D. E. Lesemann. 1980. Ann. Appl. Biol. 94:61-68

**Laemmli, U. K., and M. Favre. 1973. J. Mol. Biol. 80, 575-599.

***AVRDC.1984 Progress Report. Shanhua, Tainan, Taiwan.

Table 20. Comparative host range of AzMV, BICMV, and the unknown poty virus.[z]

Host	AzMV[y]	BICMV[x]	Unknown P. Virus[w]	Host	AzMV[y]	BICMV[x]	Unknown P. Virus[w]
G. max				*P. vulgaris* (con't)			
Bragg	–	–	M	Jubila	–	–	N,LL
Rampage	–	–	M	Black Turtle	–	–	cLL
Oden	–	–	M,N	BT-1	–	–	LL
Davis	–	–	M,N	BT-2	M,Mal	N	Y,M,St
Buffalo	–		M,N	Bountiful	M	M	M
Marshall	–	–	M,N	Monroe	cLL	cLL	cLL
KS-8	–	–	M	Kentucky Wonder Waxpole	–	NT	N,Death
York	M	–	M,N	Immuna	–	–	–
Jupiter	M	–	M	Amanda	–	–	–
HL-1	M	–	M	*V. unguiculata* subsp. *sesq.*			
Iwate-Wasekurome	M	–	M	FTHES CP72	Mot	Mot	Mot
HLS	–	–	–	FTHES CP1	Mot	M	Mot
Shih Shih	–	–	–	FTHES CP22	–	M	Mot
TN-15	–	–	–	*V. unguiculata*			
P. vulgaris				Early Ramshorn	NT	M	M
Redlands G.L.B.	–	–	Mot	Blackeye	–	M	M
Redlands G.L.C.	–	–	Mot	FTHES CP30	–	–	–
Imp. Tendergreen	–	–	N,D	FTHES CP29	Mot	–	–
Dubbele Withe	–	–	M	Local Cv. White Pod	–	M	–
Topcrop	–	–	N,D	*V. angularis*			
Harvester	–	–	N,D	Odate 1	M	M	M

[z]M = mosaic, Mot = mottle, N = necrosis, Mal = malformation, St = stunt, Y = yellowing, cLL = chlorotic LL, NT = not tested, D = death. [y]Iizuka's isolate. [x]Provvidenti's isolate. [w]Isolates PN, PM, 74.

Table 21. Stability of isolates PM, PN, and 74 in crude sap.[z]

Virus	TIP (°C)	LIV 20°C (Days)	DEP
PM[y]	65-60	17	10^{-4}-10^{-5}
PN[y]	50-55	23	10^{-5}-10^{-6}
74[y]	50-55	21	10^{-5}-10^{-6}
BCMV[x]	55-60	7-8	10^{-3}-10^{-4}
AzMV[x]	55-60	2-7	10^{-4}-10^{-5}
BICMV[x]	65	2	10^{-4}
SMV[x]	55-60	1-4	10^{-3}-10^{-4}

[z]TIP = thermal inactivation points; LIV = longevity *in vitro*; DEP = dilution end point. [y]Crude sap of *G. max* TN-4 diluted 1:10; assay host, *C. amaranticolor*. [x]Data from Boswell, K. F. and A. J. Gibbs, (eds.) 1983. Viruses of legumes. Virus Identification Data Exchange, Australian National Univ., Canberra.

Cells of *N. benthamiana* infected with isolate PN contained cytoplasmic cylindrical inclusions comprising pinwheels and curved laminated aggregates similar to those induced by BICMV and cowpea aphid-borne mosaic virus (CaMV).

The three unknown viruses have a coat molecular weight of 35,500 daltons, which is identical to that of AzMV, but only 500 daltons lower than that of both BICMV and BCMV-NY15 which is 36,000 daltons. CaMV (34,500 daltons), BCMV-NL5, and SMV (both 33,000 daltons) have lower weights. This result strongly supports earlier findings by comparative ELISA serological tests, using the same viruses, in which the strongest reactions occurred with homologous antisera, followed by antisera to AzMV and BICMV. Weak reactions were produced with SMV antiserum and no reactions were obtained with CaMV and BCMV-NL5.

Conclusion

The host range did not prove to be very useful for the identification of the virus. However, by serological tests and molecular weight, the virus was shown to be very closely related to both adzukibean mosaic virus (AzMV), blackeye cowpea mosaic virus (BlCMV),and the NY-15 strain of BCMV. Exact identification will be attempted by comparing their inclusion body proteins. Should it also fail, a comparison of C-DNA's of the three viruses will be necessary.

Effect of the Soybean Virus Isolate PN on Yield of Soybean Plants

Introduction

A new poty virus was frequently isolated from soybean in Taiwan. The virus has not been exactly identified. However, on the basis of serological tests and SDS polyacrylamide gel electrophoresis of the coat protein, it is assumed to be closely related to blackeye cowpea mosaic virus (BlCMV) and adzukibean mosaic virus (AzMV). The virus has a wide host range among leguminous crops and is transmitted in a nonpersistent manner by aphids. To assess the importance of this virus, its effect on yield of soybean plants was determined at different stages of plant development.

Materials and Methods

The experiment was planted on April 18. Two soybean lines, KS 8 and AGS 216, previously found susceptible to the unknown virus (isolates PN, PM, and 74) were tested. The soybean cultivar Shih-Shih (Acc. G 38) was included as a resistant check.

Plot size for each line was 5 x 1 m and consisted of one double row. One hundred seeds were planted per row (two seeds per hill). Spacing was 10 cm between hills and 50 cm between rows.

Treatments consisted of seven successive inoculations, carried out at weekly intervals from 26 April to 11 June. The plant development stage at the seven different inoculation times were the cotyledon, 1st trifoliate, 3rd trifoliate, 5th to 6th trifoliate, 7th trifoliate, 8th to 9th trifoliate, and the 10th to 11th trifoliate stage. One double row of each line remained uninoculated for control. Treatments were completely randomized within each block which were replicated three times (randomized complete block design).

Inoculum was obtained by homogenizing one part symptomatic leaves of *Glycine max* TN 4 plants in five parts of 0.01 M phosphate buffer (pH 7.0) 14 days after inoculation.

Data collected included yield, 100-seed weight, percent seed germination, and percent transmission of PN in the harvested seed.

Results and Discussion

Results are shown in Table 22. Most of the parameters measured were drastically affected by the virus at any stage of plant growth at the time of inoculation.

In susceptible plants, inoculations at any stage of plant development affected seed yields significantly. Early inoculations generally resulted in higher yield decreases and lower 100-seed weights than later inoculations.

Uninoculated plants of cultivar AGS 216 produced an average of seven times more seed than early inoculated plants (V1-V8) and at least twice as many seeds as plants inoculated between the R1 and R3 stage. Plants inoculated at the R4 stage yielded 21% less seeds than the uninoculated check.

Uninoculated plants of cultivar KS 8, on the other hand, produced approximately four times more seeds as plants inoculated at the V1 and V2 stage, and an average of 1.5 times more seeds as plants inoculated later (V5-R3). The immune soybean cultivar G 38 showed a significant yield reduction of 29% only when the plants were inoculated at the V-1 stage. Yield losses ranged between 4 and 13% at the later stages, but these values were not significant.

Table 22. Effect of inoculation with PN on soybean yield and 100-seed weight at different stages of plant development.

Time of Inoculation[z]	Yield Per Plant (g)			100-Seed Weight (g)		
	AGS 216	KS 8	G 38	AGS 216	KS 8	G 38
9 (V-1)	1.1 d	1.0 e	6.2 a	9.4 e	11.6 c	15.9 a
20 (V-2)	1.7 d	1.6 e	6.8 a	11.6 d	11.2 c	15.6 a
27 (V-5)	1.5 d	4.8 d	6.4 a	12.4 dc	14.6 b	16.3 a
34 (V-8)	1.4 d	5.1 dc	7.0 a	11.8 dc	15.9 b	16.5 a
42 (R-1)	3.5 c	4.9 d	6.6 a	13.6 bc	16.1 b	15.8 a
48 (R2/3)	4.9 c	6.4 b	6.9 a	15.2 b	15.0 b	15.7 a
55 (R-4)	7.8 b	6.5 b	6.7 a	17.1 a	16.3 b	16.5 a
Check	9.8 a	7.9 a	7.4 a	18.8 a	18.0 a	16.3 a
LSD (0.05)	1.5	1.09	1.69	1.72	6.38	2.44
CV %	21.61	12.85	14.59	7.14	1.66	0.68

[z]Days after sowing. Numbers in parentheses indicate stage of plant development at time of inoculation.

Similarly in the 100-seed weights, there were significant differences which were most pronounced in early inoculated plants. When the two susceptible lines AGS 216 and KS 8 were inoculated at the cotyledon stage, the 100-seed weight was significantly reduced by 50 and 40%, respectively. On the other hand, in the immune line G 38 it was reduced by only 8%.

The reduction in yield and 100-seed weight of the immune line is believed to be caused by a very small percentage of susceptible individuals among the immune plant population, indicating that this line may not be genetically pure with respect to its gene(s) for resistance to SMV-G1.

Mottling of the seed coat appeared to be strongly associated with virus infection. The two susceptible lines, KS 8 and AGS 216, produced seeds with highly mottled seed coats upon inoculation with the virus. Highest seed-coat-color intensity and highest percentage of mottled seeds were observed when plants were inoculated between the V1 and the R1 stage (Table 23).

There was also a significant percentage of mottled seeds in G 38, the resistant parent, which observation, as stated before, may be explained by a small number of susceptible individuals within the generally immune plant population. A low percentage of mottled seeds was also recovered from the noninoculated checks of the two susceptible cultivars. This probably reflects a low percentage of natural infection with PN or possibly other viruses. The germination rates have not yet been statistically analyzed; however, the germination rate of both mottled and unmottled seeds appeared to be reduced in virus infected KS 8.

In AGS 216, the other susceptible line, the germination rate of both mottled and unmottled seeds was low and erratic. This is in part attributed to the generally low seed quality produced in this line upon infection with virus isolate PN, which induces systemic necrosis and stunting in this cultivar. In the resistant line G 38 only the germination rate of mottled seed appeared to be reduced. Discoloration of the seed coat was not found to be an indication of virus presence in the seed.

Seed transmission at a low percentage (2%) was found only in mottled seeds of KS 8 inoculated at the V1 stage. All other seeds did not produce virus-infected plants. It is, however, possible that some of the seeds that did not germinate might have contained the virus. This is presently under investigation.

Conclusion

The importance of soybean virus isolate PN was assessed on the basis of host range, its mode of transmission, and by the assessment of its effect on yield of soybean, its natural host. Significant decreases in yield and 100-seed weight can be attributed to infection of soybean with isolate PN at all growth stages of the soybean. Virus-infected plants produced a high percentage of mottled seeds; however, neither high percentage nor high intensity of seed-coat mottling appeared to be associated with the virus in the emerging seedlings.

Table 23. Seed coat color, germination rate, and seed transmission of isolate PN at different growth stages of soybean plants.[z]

Cultivar or Line	Time of Inoculation	% Mottled Seeds	ISCM	% Germination		% Seed Transm.	
				nms	ms	nms	ms
KS 8	V-1	90 a	+ + + + +	67	52	0	2
	V-2	90 a	+ + + + +	64	59	0	0
	V-5	71 a	+ + + + +	51	48	0	0
	V-8	79 a	+ + + + +	48	41	0	0
	R-1	79 a	+ + + +	92	84	0	0
	R-2/3	48 b	+ + +	96	91	0	0
	R-4	45 b	+ +	96	88	0	0
	CK	3.4 c	+	96	90	0	0
AGS 216	V-1	96 a	+ + + + +	20	17	0	0
	V-2	72 b	+ + + + +	15	12	0	0
	V-5	89 ab	+ + + + +	12	6	0	0
	V-8	93 a	+ + + + +	6	3	0	0
	R-1	85 ab	+ + + + +	12	3	0	0
	R-2/3	44 c	+ +	52	38	0	0
	R-4	30 d	+ +	73	23	0	0
	CK	5.0 e	+	85	17	0	0
G 38	V-1	5.8 a	+	80	55	0	0
	V-2	7.1 a	+	96	78	0	0
	V-5	6.3 a	+	82	76	0	0
	V-8	2.3 b	+	89	67	0	0
	R-1	2.5 b	+	92	59	0	0
	R-2/3	2.3 b	+	93	29	0	0
	R-4	0.9 b	+	97	43	0	0
	CK	0.4 b	+	93	61	0	0

[z]ISCM = intensity of seed coat mottling; nms = nonmottled seeds; ms = mottled seeds.

Because of its wide host range within the legume family, its seed transmission, and the reduction in yield, this virus is considered important enough to be included in the AVRDC disease-resistance breeding program for soybean.

Seed Transmission of Soybean Virus Isolates 74 and PM

Introduction

The rate of virus seed transmission can be evaluated by different methods, the most common being a direct seed test of pooled or individual seeds by serology or bioassay, or by visual observation of grown seedlings. However, results obtained by these two tests cannot always be correlated because the presence of the virus in the seeds does not always imply infection of the emerging seedling. Also, some virus-infected seeds may fail to germinate, thus, the rate of virus transmission in the progeny test may be underestimated.

This study compared the detection of PM and 74 by directly testing the seeds and by the growing-out test to determine if there is a correlation between seed-coat mottling and the rate of virus transmission and germination.

Materials and Methods

Seed transmission of isolate PM and 74 was tested in two local soybean cultivars, KS 9 and TN 4. The plants were mechanically inoculated with the virus isolates at the cotyledon stage. Seeds were

collected and tested for presence of virus after four months of storage either by testing 200 individual seeds directly by ELISA, or by visually observing symptoms on 200 grown seedlings. At the second trifoliate leaf stage of symptomless seedlings, 10 random samples consisting of one leaf each of the randomly selected plants were tested by ELISA for symptomless infection. ELISA values were considered positive, when they were more than twice the mean values of two healthy controls.

Seeds of soybean cultivars TN 4 and KS 9 mechanically inoculated with isolate 74 or PM at the cotyledon stage, were tested after four months of storage for virus presence, either directly by an ELISA test of individual seeds, or by visual observation of grown seedlings. Plants showing symptoms were tested individually and symptomless plants were tested in pooled samples by ELISA using the immunoglobulin and enzyme conjugate at dilutions of 1:500.

Results and Discussion

The results are shown in Table 24. Seed transmission was detected in both soybean cultivars for isolate PM in the ELISA test of individual seeds. Seed transmission was not detectable in grown seedlings. This can be attributed to either the low percentage of seed transmission, which is not detectable in a sample of 200 seeds, or to the failure of virus-infected seeds to germinate. Another possibility also exists: although the virus may be detectable in the seeds, it may be inactivated by enzymatic processes during germination and, thus, cannot be detected in seedlings emerging from infected seeds.

The fact that unmottled seeds were found to contain the virus indicated that seed coat color was not necessarily correlated with virus infection.

Isolate 74 was not seed transmitted in the two cultivars. This indicates that seed transmission was either absent or too low to be detected in the small sample size of 200 seeds.

Conclusion

Seed transmission is extremely low (0.5% or less); for a reliable assessment of seed transmission a greater sample size will be needed. Seed coat color associated with virus infection did not necessarily imply the presence of the virus in the seed, since the virus was also detectable in unmottled seeds. Directly testing seeds appeared to be more reliable than observing grown seedlings for detecting virus in the seeds. However, it could not yet be determined if the presence of virus in the seeds also implied infection of the emerging seedlings. More seeds and seedlings will have to be tested to ascertain this.

Table 24. Transmission of virus isolate PM and 74 through soybean seeds tested by ELISA in seeds and seedlings.

Cultivar	Virus Isolate	% Seed Transmission			
		direct ELISA		after pregermination[z]	
		mottled	nonmottled	mottled	nonmottled
KS 8	Pm	0	0.5	0(93)	0(98)
	74	0	0	0(81)	0(82)
TN 4	PM	0	0.5	0(77)	0(55)
	74	0	0	0(59)	0(53)

[z]Numbers in parentheses refer to germination rate percentage.

Production Systems Program

Agricultural Economics

Postharvest Losses and Marketing Costs of Cabbage

Introduction

The appropriateness of a technology depends on both technical and cost efficiency. This study was conducted to determine the effect of type of container and trimming practices on postharvest losses and marketing costs for cabbage grown in both lowland and highland areas of Taiwan.

Materials and Methods

Weight loss, percent salability, and marketing costs were the three factors used to measure the efficiency of packing materials and trimming practices for cabbage. Weight loss was the difference between weight at packing and at various stages during the marketing sequence and is expressed as percentage. Salability is the salable weight of the cabbage head as a percentage of the edible weight of the head. The reduction in salability was caused by damage to inner leaves (including wrapper leaves) during postharvest handling.

Marketing costs considered in this study consisted of those variable costs related to packing materials and trimming practices. Therefore, containers, freight, and value reduction due to weight loss and physical damage were the major components of marketing costs in this study.

Lowland cabbage was grown commercially in two fields (5 km apart) of Chiayi County and harvested by the researchers. The first field was harvested on May 8; the second had three consecutive harvests on June 5 to 7, 1985.

A third experiment was conducted in Taipei County on highland cabbage (about 600 m above sea level) which was harvested on 9 June 1985. The quality of highland cabbage was much better than that of lowland cabbage in terms of freedom from decay and insect damage. However, the quality of cabbage of each harvest was average or above average in comparison to that of nearby cabbage-producing areas.

Trimming treatments consisted of five to six wrapper leaves remaining (not trimmed); two to three wrapper leaves remaining (partially trimmed); no wrapper leaves remaining (totally trimmed). Each cabbage head was weighed and marked at the time of packing. The average reduction in head weight due to trimming was 0 (not trimmed), 12 to 14% (partially trimmed), and 17 to 19% (totally trimmed). In the first experiment a fourth treatment consisted of totally trimmed cabbage wrapped in an EVA film. However, the EVA film resulted in decay on the cabbage butts and was not repeated.

Cartons or disposable bamboo baskets were used as containers. Each container was considered a replication and there were five replications per treatment. In Taiwan, the basket is the most common cabbage container and is quite uniform in size. Average packed weight for baskets was 29 to 31 kg for lowland cabbage and 26 to 32 kg for highland cabbage.

However, there was no cabbage carton in Taiwan, so the type of carton used depended on what was available in the local area. Lowland cabbage was packed in cauliflower cartons which were more appropriate than the peach or orange cartons which were available in the highlands. With lowland cabbage, closer trimming resulted in heavier carton weight; the reverse was true for the highland cabbage. Across treatments, lowland cabbage averaged 19 to 20 kg per carton and highland cabbage, 13 to 14 kg.

After packing, cabbage was commercially transported from the growing area to the Taipei auction market. The containers were picked up at the market by 8:00 A.M. on the day of arrival (the day after harvest) and transported to National Taiwan University (NTU) where evaluations were made. For the first experiment each head was evaluated for weight loss and damage on the day of arrival (1 day after harvest) and again at 3 and 5 days after harvest. The additional holding times were to simulate the maximum period of time usually encountered in the marketing chain. However, due to the fact that most postharvest losses in cabbage were evident on the day of arrival, the additional holding period and examinations were eliminated for the later experiments.

Results and Discussion

Weight loss. The weight loss of cabbage from the first harvest was 5 to 6% after transport (Table 1). The additional four days at ambient temperatures brought the total loss of weight to approximately 10 %. Weight loss during packing and transport of the later harvests was about half that experienced in the first tests (Table 2). Cabbage of the first harvest was exposed to the sun during trimming and packing, while cabbage of later harvests was moved to the shade immediately after harvests.

Table 1. Weight loss and salability of cabbage harvested in Chiayi County, 8 May 1985.

Treatments/Containers	Weight Loss (%)[z]			Salability (%)[y]		
	L1	L2	L3	S1	S2	S3
Basket	5.89	1.79	2.45	66.00	94.46	96.19
Carton	4.04	0.99	1.69	93.20	96.69	95.62
Not trimmed	5.47	1.34	2.46	72.10	94.89	96.67
Partially trimmed	5.67	1.79	2.61	87.10	95.27	95.91
Totally trimmed	5.89	2.02	2.33	75.80	95.84	95.93
Totally trimmed and wrapped in EVA film	2.83	0.33	0.85	79.40	96.56	95.17
Not trimmed, basket	7.45	1.64	2.62	53.90	93.96	96.65
Partially trimmed, basket	6.87	1.92	3.64	78.30	93.85	95.49
Totally trimmed, basket	6.87	2.95	2.70	63.00	94.04	96.21
Totally trimmed and wrapped in EVA film, basket	3.25	0.67	0.88	68.90	95.76	96.58
Not trimmed, carton	4.00	1.12	2.35	94.36	95.52	96.68
Partially trimmed, carton	4.58	1.67	1.67	97.03	96.45	96.29
Totally trimmed, carton	5.25	1.25	2.04	91.69	97.34	95.71
Totally trimmed and wrapped in EVA film, carton	2.46	0.05	0.83	90.60	97.24	94.04

[z]Weight loss L1, L2, and L3 are percent weight loss of cabbage after 1 day, between 1 to 3 days and 3 to 5 days after harvest, respectively. [y]Salability = edible weight (no wrapper leaves) − trimming loss due to injury or decay/100. S1 was determined the day after harvest; S2 and S3 were due to additional trimming losses incurred between 1 and 3 and 3 and 5 days, respectively.

In general, percent weight loss of lowland cabbage in bamboo baskets was highest for the untrimmed with little difference between the partially and totally trimmed treatments. Cabbage from the highlands did not conform to this general trend, nor did any of the trimming experiments that were packed in cartons. However, cabbage in cartons lost less weight than that in baskets regardless of trimming. The EVA film was effective in reducing weight loss, particularly when the cabbage was packed in cartons.

Salability. The first harvest, between 54 and 78% of the edible portion of cabbage packed in bamboo baskets, was salable. This compared with 91 to 97% salable portions in cartons. The high losses in these tests were because of the somewhat overmature cabbage and the heads bursting open during transport which resulted in loss of the entire head. Since the cartons were more fragile and also weighed less than the baskets, they were handled more gently, and consequently, had fewer bursted heads. In later tests, the cartons carried more salable cabbage than the baskets only in the totally trimmed treatment.

In later harvests, protection by the outer leaves significantly increased cabbage salability. Also, highland cabbage had higher salability than lowland cabbage.

Table 2. Weight loss and salability of cabbage one day after harvest.[z]

Treatments/Containers	Weight Loss (%)		Salability (%)[y]	
	lowland	highland	lowland	highland
Not trimmed	2.79	2.95	98.10	99.94
Partially trimmed	2.29	2.73	97.86	99.96
Totally trimmed	2.03	3.25	93.31	97.96
Basket	2.69	3.63	95.88	98.87
Carton	1.75	1.62	96.39	99.78
Not trimmed, basket	3.40	3.78	98.11	99.90
Partially trimmed, basket	2.48	3.11	97.94	99.95
Totally trimmed, basket	2.41	3.96	92.65	97.34
Not trimmed, carton	1.84	1.39	98.07	99.98
Partially trimmed, carton	2.01	1.95	97.74	99.98
Totally trimmed, carton	1.48	1.50	94.26	99.43

[z]Average water loss and salability of lowland cabbage harvested in Chiayi County during 5 to 7 June 1985; and of highland cabbage harvested in Taipei County, 9 June 1985. [y]Salability = edible weight (no wrapper leaves) − trimming loss due to injury or decay/100.

Marketing costs. Marketing costs for lowland cabbage of the second harvest and those for highland cabbage are shown in Tables 3 to 4. Cost of containers, freight, and value reduction due to postharvest losses were calculated for cabbage from all trimming practices and container combinations based on 1 t of totally trimmed cabbage.

Since 1.2 t of untrimmed cabbage or 1.1 t of partially trimmed cabbage was required to equal 1 t of totally trimmed cabbage, the cost of containers and freight was inversely proportional to the degree of trimming.

Quantity reduction due to weight loss and damages was converted into value reduction based on wholesale market prices. Weight loss did not differ according to trimming practices, but value loss due to damages did. In general, postharvest losses for trimmed cabbage were offset by lower freight and container costs.

Table 3. Marketing costs for 1 t of totally trimmed (edible) lowland cabbage packed in bamboo baskets or fiberboard cartons and on three methods of trimming.[z]

Marketing Costs	Not Trimmed		Partially Trimmed		Totally Trimmed	
	basket	carton	basket	carton	basket	carton
Weight (kg/container)	29.23	18.77	30.01	19.44	30.67	20.20
Conversion rate based on totally trimmed cabbage (%)	83.15	82.82	89.64	90.38	100.00	100.00
Amount of cabbage to obtain 1000 kg totally trimmed cabbage (kg)	1203.00	1207.00	1116.00	1106.00	1000.00	1000.00
Number of containers used	41.00	64.00	37.00	57.00	33.00	50.00
Cost of containers (NT$)	779.00	1088.00	703.00	969.00	627.00	850.00
Freight (NT$)	1023.00	1026.00	949.00	940.00	850.00	850.00
Loss of the edible portion of the cabbage head due to mechanical injuries (NT$)[y]	69.00	70.00	75.00	82.00	267.00	208.00
Total (NT$)	1871.00	2184.00	1727.00	1991.00	1744.00	1908.00

[z]The average marketing costs of cabbage harvested in Chiayi County, 5 to 7 June 1985. [y](1000 kg totally trimmed cabbage) x (100% − percent salability) x (NT$3.63 per kg totally trimmed cabbage) was estimated by the way stated above.

Conclusion

Outer leaves did not protect cabbage effectively from weight loss but preserved it from mechanical injuries during transportation. Cabbage with wrapper leaves incurred higher freight and container costs. The EVA film reduced water loss significantly; however, its enhancement of decay on the butts made its use questionable.

Table 4. Marketing costs for 1 t of totally trimmed (edible) lowland cabbage packed in bamboo baskets or fiberboard cartons and on three methods of trimming.[z]

Marketing Costs	Not Trimmed		Partially Trimmed		Totally Trimmed	
	basket	carton	basket	carton	basket	carton
Weight (kg/container)	25.60	14.41	28.05	13.73	31.83	12.78
Conversion rate based on totally trimmed cabbage (%)	81.75	81.37	91.91	90.54	100.00	100.00
Amount of cabbage to obtain 1000 kg totally trimmed cabbage (kg)	1222.00	1229.00	1088.00	1104.00	1000.00	1000.00
Number of containers used	48.00	85.00	39.00	80.00	31.00	78.00
Cost of containers (NT$)	912.00	1446.00	741.00	1360.00	589.00	1326.00
Freight (NT$)	349.00	351.00	311.00	315.00	286.00	286.00
Loss of the edible portion of the cabbage head due to mechanical injuries (NT$)[y]	7.00	1.00	3.00	1.00	182.00	39.00
Total (NT$)	1268.00	1795.00	1055.00	1676.00	1057.00	1651.00

[z]Marketing costs of cabbage harvested in Taipei County, 9 June 1985. [y](1000 kg totally trimmed cabbage) x (100% – percent salability) x (NT$6.85 per kg totally trimmed cabbage) was estimated by the way stated above.

Cartons were effective in reducing mechanical damages to overmature and totally trimmed cabbage. Cartons also resulted in less weight loss. Therefore, properly designed cartons might be able to increase marketing efficiency in some cases. In this study, however, trimming and packing in baskets were more cost-effective.

Postharvest Losses in Thailand, Indonesia, and the Philippines

Introduction

Observation reports on postharvest losses of perishable crops in Southeast Asia were written by four specialists who made trips to three countries to observe postharvest handling of these crops.* Their observations were condensed into one report of the Postharvest Institute for Perishables (PIP) called, *Postharvest Loss Investigations in Thailand, Indonesia and the Philippines*, by Harvey C. Neese. This is a summary of some of the highlights from that report.

The objectives of this study were 1) to observe postharvest handling of horticultural crops in three countries; 2) to identify postharvest problems common to all the countries; and 3) to identify local facilities or capabilities for solving the problems.

Materials and Methods

Observations and interviews were conducted by the four specialists in the three countries. Because of the commonality of postharvest problems in the three countries, the specialists grouped together the problem areas for analysis and discussion.

Results and Discussion

All three countries have common characteristics. They are in hot, tropical areas with relatively large land areas spread out over considerable distances. Roads other than main arterials are generally poor in these places. They can or do produce somewhat the same vegetables or fruit crops. Finally, all are suspected of having large postharvest losses in perishable crops with limited personnel and financial commitments to reduce these losses.

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Five problem areas have been described by the specialists:

1. Handling technology. The handling of vegetables and most fruits has not advanced significantly in the past several decades. There is still no premium price paid for grading produce, and standards have not been established in vegetables and most fruit species.
2. Containers. The standard shipping container is a flexible basket made from split bamboo. These containers can be packed tighter than rigid containers, and are frequently overpacked in transporting vehicles, almost guaranteeing sub-quality products at arrival points.
3. Refrigeration and storage. Refrigerated vehicles and cold storage facilities are inadequate but do appear to some extent in large urban areas. Growers do not have facilities to remove field heat from fruits and vegetables prior to shipping. Losses usually begin with the handling of produce during and immediately after harvest.
4. Extension of postharvest technology. Extension of practical postharvest technology has been slow to take effect, and it is not reaching those who might benefit from the information. Some reasons are inadequate funding commitments, too few specialists in postharvest activities, lack of incentives for the private sector to improve food quality, substantial investments required, insufficient practical information received by end-users, and difficulties in breaking down traditional barriers.
5. Data on postharvest loss. Postharvest losses of perishables are largely based on estimates, not on accurate data. There has been little research on the economics of postharvest losses to establish what percentage of losses is economically acceptable. There are also insufficient data to show that improvements in postharvest technology are economically viable.

Some recommendations were made by the specialists based on their observations and interviews:

1. Information exchange. An information exchange is proposed between PIP and AVRDC. AVRDC would act as the Asian repository for postharvest research information collected and stored by PIP. Data would be distributed through requests to AVRDC.
2. Development of a training course and field manual. A training course on identification and assessment of postharvest losses would emphasize what to look for and how to use the information after it has been collected. The manual would focus on the process of identifying postharvest losses. The target group for both would be mid-level personnel from developing countries.
3. Support of postharvest organizations. There is an immediate need to support organizations and extension programs to reach the potential end-users of postharvest information. Research results that have been obtained are not getting out to where the losses are occurring.
4. Development of a postharvest center. There is a need for a regional or international postharvest loss center in Asia for vegetables. This center would provide technical assistance, training, and transfer of applied research to postharvest loss areas.
5. Container research. There is a need for research on traditional bamboo containers used in transporting perishables. Bamboo or thatch baskets are utilized to transport many perishable crops in Asia. It is expected that these types of containers will continue to be used. Research is needed on estimating losses attributed to the use of these baskets, and strengthening the frames if losses are found to be substantial.

The report also contains a listing of organizations involved in postharvest work in the three countries and their principal postharvest activities.

Crop Management

Screening for Good Artificial Seedling Media

Introduction

The standard AVRDC seedling medium is composed of a 5:1:3:1 ratio of soil, sand, compost, and rice hull. Its characteristics can vary depending upon the source and condition of the soil used. When the soil has a high proportion of clay, the drainage of the medium is not adequate and care must be taken not to water the seedlings excessively. The objective of this trial was to determine if an improved medium could be developed by blending locally available components.

Materials and Methods

Locally available materials which were mixed together included sand, crotalaria compost, rice hulls, and burnt rice hulls. Combinations of 29 media were blended and 12 pots (4.5 cm bottom × 6.5 cm top × 7.5 cm height) of each were filled and seeded with Chinese cabbage. The experiment was repeated and fresh weights of the seedlings were determined 15 and 17 days after seeding. Seedlings were foliarly fertilized twice.

Results and Discussion

The best-performing media were the combinations of sand crotalaria compost, rice hulls, and burnt rice hulls on the 2:4:0:1 and 1:2:0:0 ratios (Table 1). Since the 4:8:0:1 medium also performed well, it can be concluded that a 1:2 ratio of sand and compost, with or without burnt rice hulls, is likewise a desirable mixture. It should be noted that the 1:2:0:1 and 1:2:0:2 mixtures did not perform as well as the 1:2:0:0 blend.

Although seedlings grew acceptably in the 1:1 sand and compost mixture, this proportion of sand tended to cause the root soil-media block to fracture more easily when seedlings were depotted. This is due to both the high bulk density and low adhesive and cohesive forces of the sand. This mixture should, therefore,be discouraged; the sand proportion of a mixture should not exceed one-third of the volume.

Plants grew well in compost alone. However, there was a tendency for compost to dry and rewet poorly. The addition of sand and/or rice hulls improved its texture and greatly increased wetting and drainage.

Addition of rice hulls also reduced bulk density of media mixtures. Seedling growth was better with burnt rice hulls than with unburnt ones. This may have been due to nutrition and should be investigated further; it would, of course, be more convenient to use unburnt rice hulls. The results and observations of these trials indicate that the ideal proportion of burnt rice hulls should be in the range of 7 to 14% of the mixture.

It is interesting to note that 17 of the media mixtures performed significantly better than the standard AVRDC media mixture in these trials.

Table 1. Relative fresh weights of Chinese cabbage seedlings growing in 29 media combinations.

	Media				Relative
	sand	c. c.[z]	rice hulls	burnt rice hulls	Fresh Wt.[y]
1)	2	4	0	1	97
2)	1	2	0	0	96
3)	0	1	0	0	85
4)	4	8	0	1	84
5)	6	6	0	1	84
6)	1	1	0	0	83
7)	0	2	0	1	82
8)	0	4	0	1	81
9)	4	4	0	1	80
10)	2	2	0	1	77
11)	1	2	0	2	72
12)	1	1	0	1	71
13)	1	3	0	3	67
14)	1	2	0	1	67
15)	2	1	0	0	65
16)	0	4	1	0	64
17)	0	1	0	1	63
18)	0	2	1	0	54
19)	2	1	0	1	54
20)	8	4	0	1	52
21)	1	1	0	2	47
22)	AVRDC standard media[x]				47
23)	0	1	0	2	46
24)	1	1	1	0	40
25)	1	1	2	0	32
26)	0	1	1	0	32
27)	1	1	1	1	28
28)	0	1	2	0	24
29)	0	0	0	1	2
LSD 5 %					15

[z]Crotalaria compost. [y]Percentage of best-performing treatment averaged over two experiments.
[x]Soil:sand:compost:rice hull = 5:1:3:1.

Conclusion

The AVRDC standard seedling medium should be improved. Media mixtures with 1:2 sand:crotalaria compost with or without 7 to 14% burnt rice hulls are recommended for further study. Addition of sand should not exceed one-third of the mixture by volume.

Effects of Five Seedling Media on the Yield of Transplanted Chinese Cabbage

Introduction

The production of strong, healthy seedlings requires a good growing medium which should supply the plants with adequate aeration, nutrition, and water. The medium should be free of diseases and have good drainage, as well as good water-retention properties.

The objective of this trial was to compare four media with the standard AVRDC medium of soil, sand, compost, and rice hull (5:1:3:1) and to compare the performance of seedlings raised in two management regimes.

Materials and Methods

The media treatments are described in Table 2. The Crop Management Department (CMD) staff raised half of the seedlings in an open-sided plastic-covered greenhouse and sprinkle-irrigated them with a total of 12.9 cm (820 ml/pot) of water during the seedling period. The Soils Department (SD) staff simultaneously raised the other half of the seedlings in a fan cooled glasshouse and flood-irrigated them with a total of 520 ml of water per pot during the seedling period.

Large polyethylene pots (9 cm top × 6 cm bottom diam. × 8.5 cm depth) were filled with media and seeded with ASVEG 1 Chinese cabbage on 12 August. Germination exceeded 89% for all treatments. The AVRDC 1:2 and 2:4:1 media treatments received foliar fertilizer applications 8 and 16 days after seeding, but they appeared to be nitrogen deficient at transplanting time. The 3:1:1 and 5:1:1 treatments did not receive additional fertilizer, but their nutrition appeared to be adequate.

The 2:4:1 medium had the best drainage followed by 1:2, 3:1:1, 5:1:1, and the AVRDC media in that order (Table 2). Drainage for the AVRDC medium was inadequate.

Seedlings were transplanted 18 days after seeding into beds (30 cm high) spaced 1.5 m apart. Each bed had two rows of plants spaced 50 cm apart with a 40 cm spacing between plants to give a density of 33,333 plants/ha. A preplant basal application of 60-80-80 kg NPK/ha, a sidedress application of 60 kg N/ha plus 40 kg K/ha at seven days after transplanting, and 30 kg N/ha at 21 days after transplanting were applied.

Table 2. Characteristics of five media.

Media Content v/v	pH	EC mmhos/cm	Drainage[z] Time (min)
Soil:sugar cane compost:burnt rice hulls 3:1:1	7.0	0.9	18
Soil:sugar cane compost:burnt rice hulls 5:1:1	6.9	0.9	37
Sand:crotalaria compost 1:2	7.9	2.4	10
Sand:crotalaria compost:rice hulls 2:4:1	7.7	1.8	2
Soil:sand:compost:rice hull 5:1:3:1[y]	7.9	0.5	89

[z]Time required for 100 ml of water to drain from a pot (9 cm top × 6 cm bottom × 8.5 cm depth) of saturated media. [y]The standard AVRDC media.

Results and Discussion

At transplanting time, seedlings raised by the SD staff were 1.5 to 2.7 g heavier than those raised by CMD except, for the seedlings growing in the AVRDC medium which showed little variation between the two regimes (Table 3). Watering may have accounted for some of these differences. Although more total water was applied by CMD, the seedlings wilted somewhat at midday; wilting did not occur in the SD glasshouse. This suggests that more frequent but smaller waterings are beneficial, because pots have a limited water holding capacity. However, it is interesting to note that there were no significant final yield differences in seedlings of either regime.

At transplanting time, seedlings in the experimental media were 2.5 to 5.5 times heavier than those growing in the standard AVRDC media (Table 3). At 14 days after transplanting, these differences increased by 3.3 to 8.5 times. The largest seedlings originated from the 5:1:1 medium followed by the 3:1:1, 1:2, 2:4:1, and AVRDC media. Final yields also followed this order (Table 4).

Chinese cabbage plants from the 5:1:1 seedling medium produced a very satisfactory salable yield of 20 t/ha which was significantly greater than that produced in the 1:2 and 2:4:1 treatments; it was nearly double the yield produced in the AVRDC medium.

It is speculated that improvements in the fertility levels of the 1:2 and 2:4:1 media at the late seedling stage would have contributed to faster growth after transplanting and, consequently, higher final yields.

Conclusion

The final salable yield of Chinese cabbage originating from seedlings grown in the medium with a 5:1:1 ratio of soil, sugar cane compost, and burnt rice hulls was nearly double that produced from

seedlings grown in the standard AVRDC medium when both treatments were transplanted and harvested on the same day.

Table 3. Fresh weights of Chinese cabbage at 0 to 35 days after transplanting in the field.

Media[z]	Plant Age[y] (days after transplanting)			
	0	7	14	35
Seedlings raised by the Crop Management Dept.				
AVRDC	1.4	2.9	15.2	678
2:4:1	3.6	9.2	49.8	901
1:2	4.3	11.6	58.1	990
3:1:1	3.6	17.5	73.1	1017
5:1:1	4.0	17.7	66.9	1058
Seedlings raised by the Soils Dept.				
AVRDC	1.2	2.1	10.7	613
2:4:1	5.1	9.1	46.7	909
1:2	5.9	12.9	67.1	977
3:1:1	5.1	20.7	74.9	1075
5:1:1	6.7	22.4	91.5	1093
LSD 5 %	0.8	3.0	21.3	128

[z]The media are described in Table 2. [y]Chinese cabbage was transplanted to the field 18 days after seeding.

Table 4. Final yield of Chinese cabbage harvested 35 days after transplanting.

Media[z]	Total Wt (t/ha)	Salable Wt[y] (t/ha)
AVRDC	21.5	10.4
2:4:1	30.2	15.4
1:2	32.8	17.7
3:1:1	34.9	18.5
5:1:1	35.8	20.0
LSD 5 %	3.1	2.0

[z]The media are described in Table 2. [y]Salable remaining inner heads after the outer wrapper leaves have been discarded.

Effect of Soil Moisture on the Emergence Rate of Direct-Seeded Mungbean and Soybean

Introduction

During dry weather, furrow irrigation usually precedes the seeding of mungbean and soybean since irrigating after seeding delays and reduces germination. Thus, the soil should be moist enough for germination but not saturated. The objective of this study is to determine the optimum soil moisture for seeding mungbean and soybean.

Materials and Methods

Raised double-row beds, 15 cm high and 1 m apart, were prepared. Plots were furrow-irrigated almost to the top of the beds to insure that the soil water was at the saturation level. Mungbean (VC 1973-A) seeds treated with PCNB and soybean (AGS 19) seeds treated with captan were seeded at a 4-cm depth immediately before irrigation or 1, 3, 7, and 10 days after the irrigation. Soybean was irrigated on 11 March and mungbean, on 18 March. Soil moisture content and seedling emergence were monitored.

Results and Discussion

Soil moisture content and tension for a 25-day period following the saturating furrow irrigations of the mungbean and soybean trials were recorded. Moisture tension remained between 0 and -0.1 bar for 3.5 to 4 days after irrigation and increased from -0.35 to -0.38 bar 10 days after irrigation. The average daily evaporation loss was 4.4 and 4.0 mm for the mungbean and soybean trials, respectively. A 12-mm total rainfall over a three day period started at day 9 for mungbean and day 16 for soybean; this caused a temporary halt in the decline of the soil moisture percentage.

Soil moisture tensions at seeding time for mungbean were 0, -0.01, -0.07, -0.23, and -0.38 bars and this corresponded to 0, 1, 3, 7, and 10 days after furrow irrigation, respectively (Table 5).

Table 5. The effect of soil moisture on the initial germination of mungbean and soybean.[z]

Days after Furrow Irrigation	Soil Moisture at planting		Tension (bars) at initial g.		Days from Sdg. to Initial 10% G.	
	mb	sb	mb	sb	mb	sb
0	0	0	-0.29	-0.37	8.1	10.5
1	-0.01	-0.03	-0.32	-0.43	7.7	10.2
3	-0.07	-0.06	-0.38	-0.43	7.0	8.4
7	-0.23	-0.23	-0.38	-0.45	4.6	6.6
10	-0.38	-0.35	-0.44	-0.51	8.3	6.4
LSD 5%					0.8	0.8

[z]G or g germination; sdg seeding; mb mungbean; sb soybean

Seeds planted at -0.23 bar moisture tension or seven days after irrigation achieved the highest total germination (84%) and also germinated most rapidly (Table 5). They required only 4.6 days to reach the initial 10% germination compared to 8.1, 7.7, 7.0, and 8.3 days for the treatments seeded 0, 1, 3, and 10 days, respectively, after furrow irrigation.

It is interesting to note that initial germination was retarded by both wet soil conditions and soil moisture tension (-0.38 to -0.44 bar) which is regarded to be adequately moist for the growth of many crops. However, there was a 70% total germination rate in the soil seeded at 10 days after irrigation; whereas only 42 to 43% germination occurred in the soil seeded at 0 to 3 days after irrigation. Thus, it can be concluded that wet soil conditions are detrimental for mungbean germination.

Soybean germination was also retarded by wet soil conditions (Table 5 and Fig. 1). The slowest initial germination and the lowest total germination rate occurred when seeds were planted at the three wettest soil conditions. It is noteworthy that total germination was higher in the three day after-

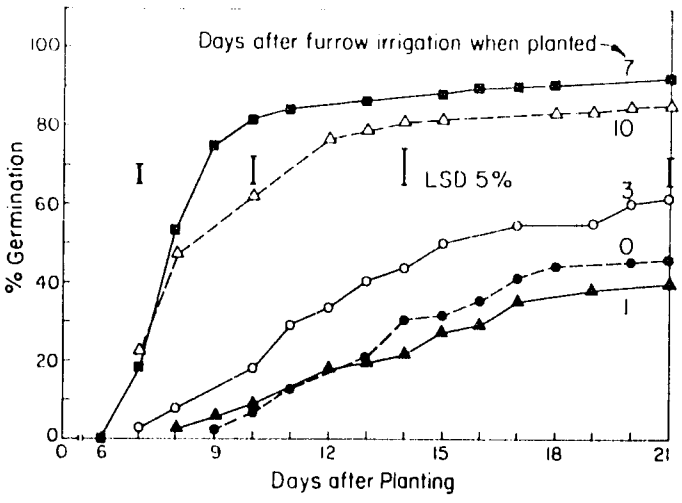

Fig. 1.
The percentage germination of soybean planted at 0, 1, 3, 7, and 10 days after furrow irrigation.

irrigation treatment (61%) than in the 0- and 1-day after-irrigation treatments (46 and 39%, respectively). The time needed for the initial 10% germination was at least 3.6 days longer for the wettest two treatments than for the driest two treatments. The seven-day after-irrigation treatment achieved the highest total germination rate (92%) and was followed closely by the 10-day after-irrigation treatment (85%).

Conclusion

Germination of soybean and mungbean is affected by soil moisture conditions. Very wet soil conditions at seeding time (wetter than a soil moisture tension of -0.07 bar) caused slower initial and less total germination of soybean and mungbean. Optimum initial and total germination occurred when seeds were planted at a soil-moisture tension level of -0.23 bar which occurred seven days after furrow irrigation.

Influence of Nitrogen Fertilization and Plant Population on Vegetable Soybean

Introduction

A previous trial reported that increasing the plant stand of feed soybeans, from 20-100 plants/m^2 did not result in higher yields. However, the number of pods per plant was more than three times greater at the lowest population than at the highest population. Since vegetable soybeans are hand-harvested, a larger number of pods per plant are gathered. Therefore, the lowest plant population without any yield loss would be preferred.

The objective of this study was to determine the effects of four plant populations of vegetable soybeans at two rates of nitrogen fertilization.

Materials and Methods

Plants were seeded at populations of 10 plants/m^2 (20 × 50 cm, one plant/hill), 20 plants/m^2 (20 × 50 cm, two plants/hill), 31 plants/m^2 (13 × 50 cm, two plants/hill) and 40 plants/m^2 (10 × 50 cm, two plants/hill). Fertilizer rates included 30-60-80 kg and 60-60-80 kg N-P-K/ha applied preplant plus 30 and 60 kg N/ha, respectively, side-dressed at one month after seeding.

In the first experiment, arranged in a split-plot design with three replications, G 9053 was seeded on 16 July and harvested on 2 October. In the second experiment, arranged in a split-split-plot with three replications, G 9053 and G 10134 were seeded on 26 September and harvested on 2 December.

Results and Discussion

The final plant stands in the field were 10.1, 18.7, 27.9 and 32.0 plants/m^2 in the first experiment and 9.5, 18.4, 26.6 and 34.4 plants/m^2 in the second experiment.

In the first experiment, total pod fresh weights of the treatment with the lowest nitrogen rate and lowest population were 17 to 24% lower than any of the other treatments. Pod yields of the other treatments were not significantly different from each other, although the highest yields were obtained with the highest nitrogen rate at plant densities of 18.7 and 27.9 plants/m^2.

A similar trend was observed with the yield of grade 1 pods (larger than 4.5 cm long × 1.4 cm wide), but no significant differences were indicated due to the high variability in pod quality. In the second experiment, nitrogen did not significantly affect any of the yield parameters. However, total pod yield for both cultivars increased with increasing population, but the maximum yield of Grade 1 pods occurred at a plant population of 18.4 plants/m^2 for G 10134 and 9.5 to 18.4 plants/m^2 for G 9053 (Fig. 2). Pod quality (i.e., the percentage of Grade 1 pods) decreased with increasing plant population.

The number of pods and total weight of pods per plant decreased with increasing plant population (Fig. 3). Since vegetable soybeans are hand-harvested, less labor would be required per kilogram of pods from sparsely populated plants.

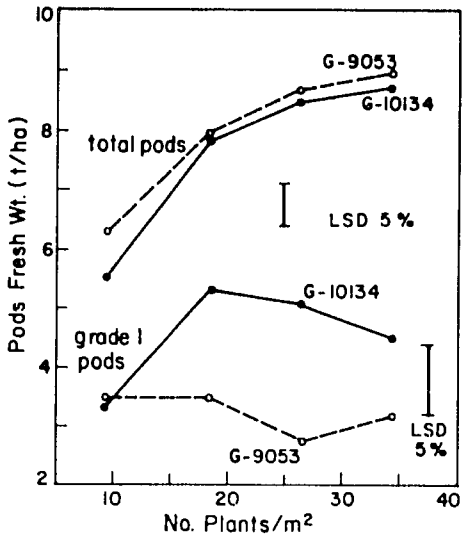

Fig. 2.
Total pod and Grade 1 pod yields of vegetable soybean G 9053 and G 10134 at four plant populations in the second experiment, 26 Sept. - 2 Dec. 1985.

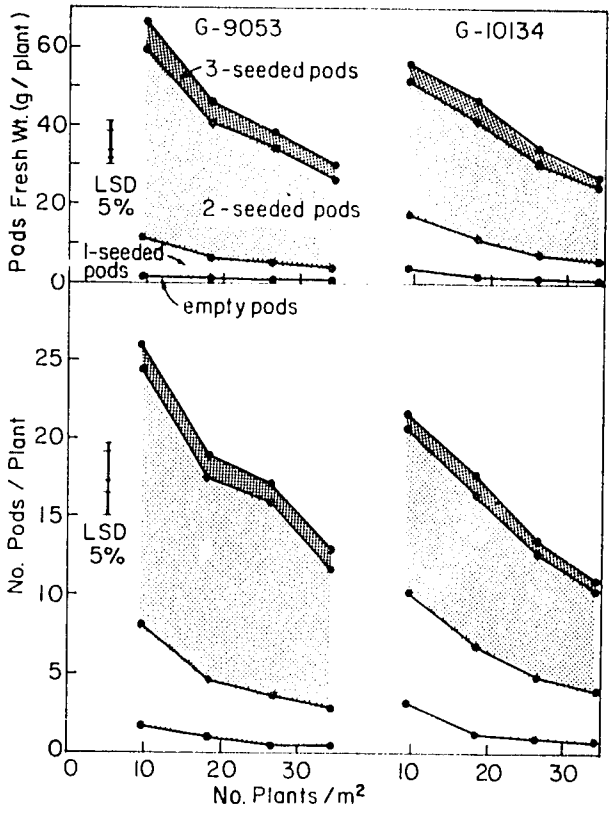

Fig. 3.
Number and fresh weight of 0-, 1-, 2-, and 3-seeded pods/plant of two vegetable soybean cultivars produced, 26 Sept. - 2 Dec. 1985.

The pods from the lowest population also were 8% heavier in the first experiment and 14% heavier in the second experiment than those from the highest population. Also, the green seed weight from the lowest population was greater than from the highest population for G 9053 but not for G 10134. Large and heavy pods and seeds are desirable characteristics for vegetable soybean.

Plant height and the number of the first podding node increased with increasing plant population (Tables 6 and 7). Conversely, the number of branches per plant decreased with increasing plant population. However, the number of nodes per plant was not affected by population.

Table 6. The effects of four plant populations and two nitrogen rates on yield parameters of G 9053 vegetable soybean planted in the first experiment.

Yield Parameter	Plant Stand[z] (plants/m²)				Nitrogen Application (kg/ha) preplant plus sidedress	
	10.1	18.7	27.9	32.0	30 + 30	60 + 60
Plant height (cm)	40.0 d	47.3 c	52.4 b	56.4 a	48.9 A	49.2 A
Branches (no./plant)	3.7 a	2.5 b	1.4 c	1.3 c	2.1 A	2.3 A
Nodes (no./plant)	10.0 a	9.8 a	9.7 a	9.8 a	9.9 A	9.7 B
First podding node/plant	1.2 c	2.0 b	2.5 a	2.5 a	2.2 A	1.9 B
Total pods/kg (no.)	417.0 c	445.6 ab	434.3 b	454.6 a	439.0 A	436.8 A
100-green-seed wt (g)	67.9 a	65.6 ab	67.4 ab	63.9 b	65.6 A	66.8 A

[z]Means within rows having the same letter are not significantly different from each other by Duncan's multiple range test at the 5% level.

Table 7. The effects of four plant populations and two nitrogen rates on yield parameters of two vegetable soybean cultivars planted in the second experiment.[z]

Yield Parameter	Cultivar	Plant Stand (plants/m²)				Nitrogen Application (kg/ha) preplant plus sidedress	
		9.5	18.4	26.6	34.4	30 + 30	60 + 60
Plant height (cm)							
	G 9053	25.0 d	28.2 c	31.4 ab	34.3 a	29.8 AB	29.7 B
	G 10134	26.3 cd	31.1 b	33.5 a	35.8 a	32.2 A	31.2 A
Branches (no./plant)							
	G 9053	3.2 a	2.3 b	1.3 c	1.0 c	1.9 A	2.0 A
	G 10134	2.1 b	1.1 c	0.6 d	0.3 d	1.0 B	1.1 B
First podding node/plant							
	G 9053	1.1 c	1.3 c	1.7 b	2.1 ab	1.6 B	1.5 B
	G 10134	1.2 c	1.8 b	1.9 b	2.3 a	1.8 A	1.8 A
100 green seed wt (g)							
	G 9053	77.2 a	72.4 b	70.5 b	71.5 b	72.5 B	73.2 B
	G 10134	78.0 a	79.6 a	80.1 a	77.6 a	78.7 A	79.0 A
Plant fresh wt (t/ha)							
	G 9053	11.7 c	14.9 b	16.4 a	17.2 a	14.9 A	15.2 A
	G 10134	10.7 c	14.5 b	16.3 a	16.9 a	14.6 A	14.6 A

[z]Separation of sub-subplot means by lower case letter(s) and of subplot means by upper case letter(s) for each yield parameter by Duncan's multiple range test, 5% level.

Plant fresh weight increased with increasing population up to about 27 plants/m², after which the rate either slowed down or decreased (Table 7).

The highest nitrogen rate resulted in 0.2 less nodes per plant and a slightly lower first podding node in the first experiment. However, these rates of nitrogen had no effect on plant height, number of branches or seed, and individual pod weight in either experiment.

Another vegetable soybean trial with G 9053 and G 10134 was planted on 25 March to a population of 40 plants/m² and gave similar yields to these trials. N-P-K treatments ranged from 60-130-120 to 210-220-200, but no significant differences in pod yields were observed. In another trial, N-P-K rates of 75-80-60 to 180-130-120 also did not affect yields of these two cultivars. Thus, from the results of these four trials, it appears that 60 kg N/ha is usually adequate for vegetable soybeans. However, this experiment also demonstrated that more nitrogen in a low plant population can result in a higher yield.

Yield data from this experiment suggest that the optimum population density for both cultivars of vegetable soybeans is 18-19 plants/m². In fact for G 9053, yields from a properly fertilized sparse stand (10 plants/m²) was not significantly lower and enjoyed the advantages of a lower seed cost, less harvesting labor required, larger pod size, and more pods per individual stem.

Conclusion

Yield and quality of vegetable soybeans are greatly affected by planting density. The optimum density for two cultivars was 18-19 plants/m^2, but G 9053 also yielded well at a density of 10 plants/m^2 with greater pod size and number of pods per plant.

Total pod yield increased 18% in one experiment but not in another at a plant population of 10 plants/m^2 when preplant plus side-dressed total nitrogen application was increased from 60 to 120 kg/ha. For higher populations, 30 kg preplant N/ha plus 30 kg side-dressed N/ha appeared adequate.

Effects of the Number and Timing of Furrow Irrigation on Vegetable Soybean during Dry Weather

Introduction

Yields of unirrigated vegetable soybean are noticeably lower during dry weather. Therefore, irrigation would be expected to increase yields of vegetable soybean growing under these adverse conditions. Since irrigation represents an added production cost, growers would like to know how many irrigations are needed. An irrigation given at a certain plant-growth stage may be more effective than at another. Thus, growers would also like to know when to irrigate.

The objective of this study was to determine the effects of furrow irrigations given at different stages of plant growth.

Materials and Methods

Soybeans were planted at spacings of 10 × 50 cm (2 seeds/hill) into plots (4 × 6 m) arranged in a randomized complete block design with four replications. A preplant fertilizer application (40-60-80 kg N-P-K/ha) was followed by a side dressing of 20 kg N/ha at flowering. In the first experiment, AGS 190 was planted on 4 March 1985 and harvested on 3 June 1985. Furrow irrigations were applied 20 days after emergence (1 April) at the beginning of flowering (19 April), of pod formation (April 30) and of pod filling (9 May).

In the second experiment, G 9053 was planted on 26 September and harvested on 4 December. Furrow irrigations were made at the beginning of flowering (23 October), of pod formation (1 November), and of pod filling (November 13).

Results and Discussion

Relatively dry weather prevailed throughout both cropping seasons, except for a heavy rainfall which occurred a week before harvest in the first experiment (Table 8). During this time, pan evaporation exceeded rainfall by nine times in the first experiment and 20 times in the second experiment. When no irrigations were given, soil moisture content decreased to 8.8% and 11.9% by the beginning of pod filling in the first and second experiments, respectively.

Table 8. Moisture conditions for experiment 2.[z]

Time of Irrigation	Soil Moisture Percentage[y]		
	Oct. 23[x]	Nov. 1[w]	Nov. 13[v]
None	14.6 (-0.45 bar)	13.2 (-0.50 bar)	11.9 (-0.55 bar)
Oct. 23	14.6 (-0.45 bar)	16.8 (-0.34 bar)	11.9 (-0.55 bar)
Nov. 1	14.6 (-0.45 bar)	13.2 (-0.50 bar)	15.4 (-0.42 bar)
Oct. 23 + Nov. 1	14.6 (-0.45 bar)	16.8 (-0.34 bar)	16.1 (-0.39 bar)

[z]26 Sept. - 4 Dec.; total evaporation was 290 mm and total rainfall was 14 mm. [y]Soil moisture percentage recorded prior to irrigation. [x]Beginning of flowering. [w]Beginning of pod formation. [v]Beginning of pod filling.

Total pod yield was higher in all of the irrigation treatments, except for a single irrigation given at the beginning of flowering in the second experiment (Table 9). When only one irrigation was given, the most effective time was at 20 days after emergence for the first experiment and at the beginning of pod formation and filling in the second experiment.

Table 9. The effects of furrow irrigation at four (experiment 1) and three (experiment 2) growth stages on yield parameters of vegetable soybean.

Time of Irrigation	Plant Height (cm)	Total Plant Fresh Wt (t/ha)	Pod with Stem Fresh Wt (t/ha)	Pod Yield (t/ha)	Grade 1 Pod Yield (t/ha)
Experiment 1[z]					
No irrigation	32.0	13.3	7.9	5.3	1.4
A[y]	39.9	20.6	12.0	7.9	1.8
B[x]	38.9	19.1	10.4	6.5	2.3
C[w]	31.6	17.7	10.4	7.2	2.4
D[v]	32.9	18.1	10.4	6.9	1.7
AB	43.5	22.3	12.8	7.9	2.4
BD	34.9	23.2	12.0	7.5	2.9
AC	39.2	22.4	13.5	9.3	3.3
AD	38.0	22.4	13.2	9.1	2.9
ABC	41.3	23.1	13.1	8.0	3.0
ABCD	42.4	25.8	15.2	9.6	4.0
LSD 5 %	4.2	2.1	1.2	0.9	1.5
Experiment 2[z]					
No irrigation	35.6	13.4	8.2	6.1	1.4
B[x]	39.4	14.1	8.4	6.1	1.7
C[w]	35.2	16.0	10.5	8.5	3.1
D[v]	37.4	17.2	11.2	8.9	2.5
CD	35.5	16.9	11.3	9.1	3.1
BD	37.8	17.5	11.6	9.1	3.1
BC	35.9	16.0	10.5	8.4	2.8
BCD	37.1	18.3	12.1	9.6	3.2
LSD 5 %	ns	3.2	2.1	1.6	1.5

[z]4 March - 3 June 1985 (experiment 1); 26 Sept. - 4 Dec. 1985 (experiment 2). [y]A: 20 days after emergence (4-1-85). [x]B: Beginning of flowering, 4-19-85 (experiment 1), 10-23-85 (experiment 2). [w]C: Beginning of pod formation 4-30-85 (experiment 1); 11-1-85 (experiment 2). [v]D: Beginning of pod filling 5-9-85 (experiment 1); 11-13-85 (experiment 2).

Highest pod yields occurred when four irrigations were given in the first experiment and three irrigations, in the second experiment. However, two irrigations resulted in similar yield increases when one irrigation was given early and the other late (at the beginning of pod filling). Lower yield increases were observed when both irrigations were given early.

In the first experiment, Grade 1 (larger than 4.5 cm long x 1.4 cm wide) pod yields were significantly higher when two (excluding the early applications), three, or four irrigations were given. In the second experiment, a single irrigation at the beginning of pod formation as well as multiple applications resulted in sizable increases of Grade 1 pods. Again, the highest yields occurred with four irrigations in the first experiment and three irrigations in the second experiment.

A single irrigation increased plant height when given early but not when given after the beginning of pod formation in the first experiment. Plant height was not affected by any of the treatments in the second experiment. Plant stand count, pod size, and the number of nodes were not significantly affected by any of the irrigation treatments.

Conclusion

Irrigation of vegetable soybeans during dry weather resulted in higher pod yields. The most effective single furrow irrigation was given at 20 days after emergence in the first experiment and at the beginning of pod formation and filling in the second experiment. Two irrigations gave better results than one and proved to be nearly as effective as three or four irrigations when one irrigation was given early and the other at the beginning of pod filling.

Effects of Leaf Removal, Cutting Length, Age of Cutting, Transplanting Method, and Spacing on Field Establishment and Sweet Potato Yield

Introduction

Presently, sweet potato cuttings, usually 30 cm long, are transplanted by hand with all of their leaves. Automatic or machine-assisted planting systems may require shorter cuttings without leaves. For example, a hand transplanter (BAK SAVER) designed for container seedlings can effectively plant straight, pencil-like, leafless cuttings but not long, crooked, leafy stems because they clog in the planting tube.

The objective of this study was to determine the preferred length and age of cuttings and to find out if high field-establishment rates and high yields could be obtained with shorter and/or leafless cuttings. In addition, the effectiveness of the BAK SAVER transplanter would be tested.

Materials and Methods

Sweet potato cuttings (30 cm long) without leaves, with all their leaves, or with only terminal leaves were planted in large pots of sand. The fresh weight of the newly emerged roots was recorded at 5 and 13 days after planting.

Sweet potato cuttings, 20 and 30 cm long, with all their leaves or with only terminal leaves were immersed in water for zero, one, and three days before planting in large pots of sand. Root fresh weight at six weeks after planting was recorded.

Cuttings, 20 and 30 cm long, of sweet potato cultivar TN 57 without leaves, with all their leaves, or with only terminal leaves were vertically immersed in a 15 cm depth of aerated or nonaerated water for zero, one, or three days before planting in the field at plant spacing of 20 or 30 cm and a row spacing of 1 m. Cuttings were planted on 18 July by hand at a slant or vertically with a BAK SAVER transplanter and were harvested on 10 December. The experiment was arranged as a randomized complete block with four replications.

In another experiment, treatments included: 1) 30 cm cuttings with no leaves removed or with only terminal leaves remaining and planted by hand; 2) 30-cm cuttings with only terminal leaves and planted with a BAK SAVER transplanter, with and without an additional covering and tamping operation. The experiment was arranged in a randomized complete block design with four replications. The plants were transplanted on 25 July and harvested on 18 December.

Results and Discussion

Removal of leaves from cuttings prior to transplanting retarded early root and plant growth (Tables 10 and 11) and early growth of cuttings but did not affect vine weight at harvest (Tables 12 and 13). In one case, marketable yield was not reduced by leaf removal (Table 12); whereas in another case, a severe yield reduction occurred (Table 13). In the former case, the soil was moist at transplanting time; in the second case, the soil was moderately dry and did not receive additional moisture for six days.

Table 10. The effect on early root growth of removing leaves from sweet potato cuttings.[z]

Leaves Removed	Fresh Root Wt. (g/plant)[y] 5 DAP	13 DAP
None	1.0	5.7
All	0.3	1.3
All except terminals	0.4	1.6
LSD 5%	0.5	1.0

[z]Cuttings were 30 cm long, collected on the day of planting, and planted 15 cm deep into sand.
[y]DAP = days after planting.

Table 11. The effects of leaf removal, cutting length, and age of cuttings on sweet potato fresh root weight six weeks after planting.

Leaves Removed	Cutting Length (cm)	Age of Cutting[z] (days)	Fresh Root Wt at 6 Wk after Planting (g)
None	30	0	24.4
	30	1	35.7
	30	3	17.9
All except terminals	30	0	11.9
	30	1	12.2
	30	3	7.5
All except terminals	20	0	7.5
	20	1	6.4
	20	3	6.7
LSD 5 %			11.0

[z]One- and three-day old cuttings were immersed in a 15 cm depth of nonaerated water.

Table 12. The effects of transplanting method, cutting age, cutting length, leaf removal, and plant spacing on early field establishment and yield of sweet potatoes.[z]

Age of Cutting (days)	Length of Cutting (cm)	Plant Spacing (cm)	3 Wk after Planting: live plants %	3 Wk after Planting: growth rating[y]	Vine Wt. (t/ha)	Marketable Yield: tubers (no./m²)	Marketable Yield: weight (t/ha)	Unmarketable Yield: Tubers (no./m²)	Unmarketable Yield: Weight (t/ha)
Transplanted by hand, no leaves removed									
0	30	30	100	4.9	18.7	6.7	9.9	9.6	3.5
Transplanted by hand, all leaves removed									
0	30	30	91	2.0	17.7	7.2	12.9	8.6	3.7
Transplanted by hand, all leaves removed except for terminals									
0	30	30	90	2.2	18.8	4.7	7.9	9.0	2.9
1	30	30	98	2.8	19.5	8.7	14.4	6.9	2.7
3	30	30	56	1.0	16.8	3.6	5.8	7.7	2.9
Transplanted by a BAK SAVER transplanter, all leaves removed									
0	30	30	78	1.3	19.8	4.9	7.8	10.5	3.2
Transplanted by a BAK SAVER transplanter, all leaves removed except for terminals									
0	30	30	76	1.2	19.6	5.0	9.0	8.7	3.0
1	30	30	79	1.5	17.0	4.2	8.1	6.2	2.4
1	20	30	75	1.5	19.2	5.2	9.7	7.1	2.3
1	30	20	94	3.0	17.2	5.4	7.6	8.4	3.3
1	20	20	81	2.0	22.4	4.2	7.7	9.3	3.3
3	30	30	44	0.8	16.8	3.2	6.5	5.8	2.0
3	20	30	9	0.2	9.9	1.2	2.3	4.1	1.3
Transplanted by BAK SAVER transplanter, all leaves removed except for terminals, cuttings were aerated									
1	30	30	83	1.9	19.7	7.7	13.2	5.7	2.3
3	30	30	85	2.6	18.3	4.5	8.2	7.8	3.2
LSD 5%			14	0.6	5.0	2.2	3.7	3.0	1.3

[z]Row spacing was 1 m; the one and three-day old cuttings were vertically immersed in 15 cm deep of non-aerated water, except for the last two treatments. [y]0 = none, 5 = best

Shorter cuttings (20 cm) produced less roots at six weeks after transplanting than longer cuttings (30 cm). Field survival, early growth, and yield were lower for the 20-cm cuttings which were immersed in water for three days prior to transplanting. When cuttings were placed in water one day prior to transplanting, 20-cm cuttings resulted in lower field survival and early growth in one case but not in another; and marketable yield was similar to that of 30-cm cuttings in both cases.

Cuttings immersed in water for one day performed better than or equal to fresh cuttings. Cuttings immersed in water for three days usually performed poorly. Roots usually require 1.5 to 2 days to initiate emergence from cuttings. These roots are often damaged in the transplanting process, thus, weakening the cutting; this was the case for the three-day treatment.

Table 13. The effects of transplanting method and leaf removal of cuttings on the early field establishment and yield of sweet potatoes.[z]

Transplanting Method	Leaves Removed[y]	3 Wk after Planting live plants (%)	growth rating[x]	Vine Wt. (t/ha)	Marketable Yield tubers (no./m²)	weight (t/ha)	Unmarketable Yield tubers (no./m²)	weight (t/ha)
Hand	None	100	5.0	18.4	7.2	9.7	10.7	3.7
Hand	AET	80	2.0	20.1	3.1	3.5	10.2	3.0
Transplanter[w]	AET	64	1.5	19.7	4.6	5.2	11.5	3.0
Transplanter + extra covering and tamping	AET	75	1.9	20.8	3.5	4.9	11.6	3.5
LSD 5 %		16	0.5	NS	2.5	3.8	NS	

[z]All cuttings were 30 cm long and were placed at a 1 × 0.3 m spacing in the field. [y]AET = all except terminals; [x]0 = none, 5 = best. [w]BAK SAVER Transplanter

On the other hand, fresh cuttings must wait for about two days after transplanting before they generate roots; whereas the one day old cuttings only need to wait for about one day. Some rotting was also observed on cuttings immersed in water for three days, but none was observed with one-day-old cuttings. For these reasons, one day old cuttings are preferred.

Planting at both 20- and 30-cm spacings resulted in similar marketable yields.

Aeration of the one day old cuttings resulted in a higher marketable yield than without aeration. Yields from aerated and nonaerated three day old cuttings were not statistically different.

The BAK SAVER transplanter did not prove to be an effective way of transplanting cuttings. Cuttings easily became lodged in the planting tube and slowed operations. In addition, this system requires additional labor for leaf removal which also resulted in lower yields under adverse planting conditions (Table 13). In the first field experiment, inexperience with the planter resulted in poorer establishment and yields in some cases (Table 12). However, in the second trial, the transplanter treatments performed as well as the hand planted treatment with only terminal leaves, but these treatments proved unequal to the present method of hand-planting cuttings with no leaves removed (Table 13).

Conclusion

Field establishment and yield of sweet potatoes were affected by the condition of the cuttings which were transplanted. Removal of leaves from cuttings reduced early root growth and resulted in lower marketable yields in one experiment. More consistent results were obtained with 30-cm than with 20-cm cuttings. Cuttings which were immersed in water for one day performed equally to or better than fresh cuttings and those immersed in water for three days.

Effects of Bed Height and Nitrogen Fertilization on Two Sweet Potato Cultivars

Introduction

High planting beds can be advantageous to summer crops because they could reduce flooding injury during wet weather. Nitrogen application rate may affect crop growth in summer, particularly if rainy weather causes leaching of nitrogen. Thus, the determination of an optimum nitrogen level has important economic implications for growers. The objective of this trial was to test the effects of two bed heights and three nitrogen rates on two sweet potato cultivars.

Materials and Methods

Sweet potato cultivars CN 1309-18 and CN 1108-13 were planted at a 1.5 × 0.3 m spacing in 30- and 45-cm-high beds on 25 July. Plots received basal N applications of 20, 40, and 60 kg/ha

followed by the same amounts, respectively, in a sidedress treatment. All plots also received a basal application of 18 kg P/ha and 80 kg K/ha followed by a side-dressing of 66 kg K/ha. The experiment was harvested on 10 December and was analyzed as a split-split plot with three replications.

Results and Discussion

Sweet potatoes growing on a bed, 30 cm high, produced significantly more vines, but the yield of marketable tubers was significantly similar to those growing on a 45-cm-high bed (Table 14). No serious flooding occurred during the growth period, and thus, a major advantage of the higher bed was not adequately tested.

Table 14. The effects of bed height and nitrogen fertilization on the yield of two sweet potato cultivars planted during summer.[z]

Treatment[y]	Vine Growth (t/ha)	Marketable Yield tuber (no./m²)	Marketable Yield weight (t/ha)	Unmarketable Yield tuber (no./m²)	Unmarketable Yield weight (t/ha)
Bed height					
30 cm	26.8 a	7.1 a	19.7 a	5.7 a	2.7 a
45 cm	25.1 b	7.2 a	18.4 a	7.1 a	3.0 a
Nitrogen rate[x]					
40 kg/ha	23.2 c	7.4 a	17.5 b	7.2 a	3.2 a
80 kg/ha	25.5 b	7.1 a	19.5 a	6.4 ab	2.7 a
120 kg/ha	29.1 a	6.9 a	20.2 a	5.7 b	2.6 a
Cultivar					
CN 1309-18	25.2 a	6.8 a	21.8 a	5.0 b	2.5 b
CN 1108-13	26.6 a	7.5 a	16.3 b	7.9 a	3.2 a

[z]Mean separation within main effects within columns by Duncan's multiple range test, 5% level.
[y]Means with main effects within columns pooled across other main effects and three replications.
[x]One-half applied preplant as a basal treatment and one-half applied as a side dressing.

Vine weight increased with increasing nitrogen rate for both cultivars. However, marketable weight of CN 1309-18 responded to increasing N rates but CN 1108-13 did not (Fig. 4). There were slightly more unmarketable tubers at the lowest N rate, but the weights from all three N treatments were statistically similar.

Both cultivars produced a similar quantity of vines, but CN 1309-18 yielded 5.5 t/ha more marketable tubers and 0.7 t/ha less unmarketable ones than CN 1108-13 when cultivar means were averaged over nitrogen and bed height means.

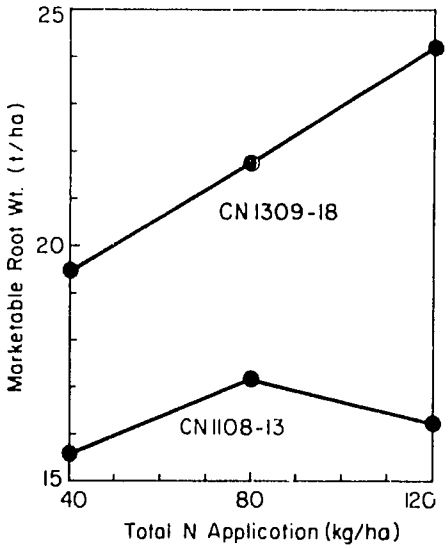

Fig. 4.
Marketable yield response of two sweet potato cultivars to three nitrogen rates.

Conclusion

Bed height and nitrogen application rates are important considerations for the production of sweet potatoes during a rainy season. In a rainy season where no flooding occurred, marketable yields of sweet potatoes growing on 30- and 45-cm beds were similar. Marketable yields of CN 1309-18 responded to increasing N rates but CN 1108-13 did not.

A Bag Culture/Rain Shelter System for Fresh-Market Tomato Production in Summer

Introduction

Summer production of tomatoes in Tainan is greatly hindered by high temperature, bacterial wilt, fungal and bacterial diseases, and fruit cracking due to frequent and/or heavy rains. Plant breeders have made significant advances in these areas, but more work needs to be done. For instance, incorporation of bacterial wilt resistance into the genotype tends to cause a greatly reduced fruit size which is not preferred by consumers. Foliar fungal diseases are likely to proliferate in warm, moist conditions where there is little air movement or under rainy conditions where fungicides are washed off when they are most needed.

It is impractical to expect plant breeding to solve these problems totally. Therefore, a management system should be devised which could overcome these obstacles to summer tomato production. This study aimed to produce acceptable yields of large fruits, decrease leaf diseases and fruit cracking, and improve fruit quality and yield by protecting plants with rain shelters.

Materials and Methods

Tomato plants were grown either in conventional soil beds or in a bag-culture method. Soil beds were 30 cm high and 80 cm wide at their top with a center to center distance between beds of 1.5 m. Plastic bags contained 30 liters of a 1:2 ratio of sand and crotalaria compost mixture. Bags were placed on a plastic sheet resting on a 30 cm-high soil bed. Thus, tomato roots were confined to the bag. There were two plants/bag with an average spacing between plants equivalent (30 cm) to that in the soil beds. There was a 1-m space between plots.

Plants were either unprotected as is the normal practice or protected with a plastic-covered rain shelter. Rain shelters consisted of bamboo frames, 2 m high, with a gable-type roof covered with vinyl plastic over which a plastic coated chicken wire was placed to provide a reliable attachment of the plastic roof. The effective width of the rain shelter roof was 0.8 m; thus, each rain shelter covered only one row and was separated from adjacent rain shelters by a spacing of 0.7 m. Rain shelters were 9 m long and adjacent ones were connected to each other by horizontal bamboo poles for added support.

Two AVRDC heat-tolerant cultivars, 5915-206-2-2-0 (large-fruited and a low bacterial wilt resistance) and 5915-553-D4-3-0 (small-fruited with high bacterial wilt resistance), were seeded 14 May, transplanted on 18 June, and harvested weekly from 12 August - 6 November. Plants were pruned twice in the first six weeks after transplanting but were allowed to grow freely thereafter. They were held upright by a trellis. All blossoms were removed on 11 October in an attempt to promote the 'sizing up' of existing fruits.

Soil beds were flood-irrigated when rainfall was insufficient. Bags were watered daily with one liter of water for the first month and 2 liters/bag daily thereafter.

Tomafix was sprayed on 13 and 26 July. There were five foliar calcium applications since blossom end rot had appeared. A soluble fertilizer (20-19-19 + micronutrients) was applied 10 times as a foliar spray for a total application of 2.1 g/plant and 11 applications were made to the soil in a dissolved form; total soil application was 27.4 g/plant. There were nine insecticide and seven fungicide applications.

Each plot had six plants, and the experiment was arranged as a randomized complete block with four replications. For 5915-206-2-2-0, the fruits were classified as follows: Grade 1 for fruits larger

than 5 cm in diameter with good shape and appearance; Grade 2 for the smaller ones; and salable offgrade for off-shaped, slightly cracked or poor-looking fruits. For 5915-553-D4-3-0, a similar grading system was used, except that the diameter for Grade 1 was larger than 3 cm.

Results and Discussion

Salable yields are shown in Fig. 5. The highest yield and quality for both cultivars were obtained in the treatment with a rain shelter over a soil bed. The large fruited cultivar, 5915-206-2-2-0, yielded nearly twice as much grade 1 fruit in the rain shelter treatment as in the unprotected soil bed and seven to eight times more grade 1 fruit than in the bag treatments. However, the total salable yield was only 17, 75, and 101% more than the unprotected soil bed, the rain sheltered plants, and the unprotected bag treatments, respectively, since all of these treatments had more offgrade fruit than the rain shelter, soil bed treatment.

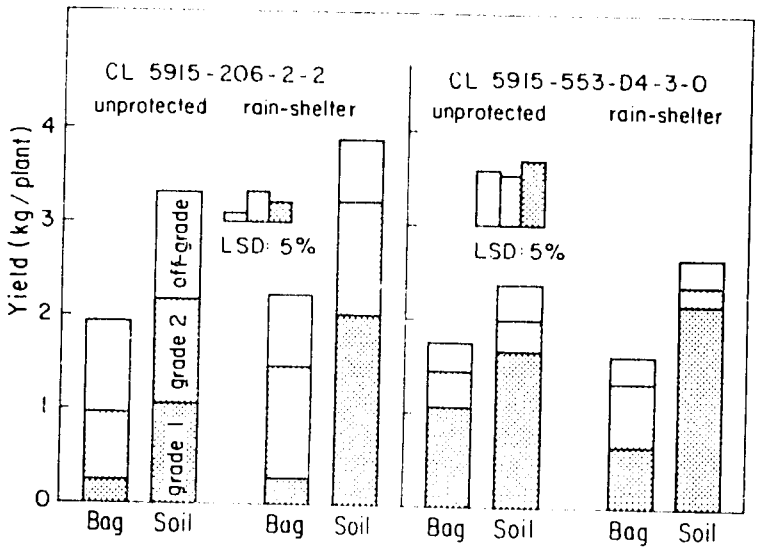

Fig. 5.
Yields of two tomato cultivars grown in bag and soil culture and which are protected or unprotected by a rain shelter.

Cultivar 5915-553-D4-3-0 tolerated rainy conditions much better. Nevertheless, similar but smaller differences occurred. However, fruit size in the unprotected bag treatment was higher than in the rain-sheltered bag treatment. This was largely due to an excessive fertilizer rate early in the season (5 g 20-19-19/plant weekly). Rainfall leached out some of this excessive fertilizer in the unprotected bag treatments and this promoted better early growth and yields. After the fertilizer rate was lowered to 1 g 20-19-19/plant weekly, the appearance of the plants improved and yields between these two treatments became similar.

Despite the lower yields in the bag treatments, all treatments exceeded 1.5 kg/plant which is considered a very good yield for summer tomatoes. Additional research on amount and type of media, fertilization practices, and water management should greatly increase the potential yield of the bag-culture method. For example, doubling the amount of media in bags located in guard rows increased yields 28 to 41% over similar treatments in the experiment.

Blossom end rot was negligible with the large fruited cultivar but became a serious problem with the rain-shelter bag treatment for the small fruited cultivar (Table 15). This was largely due to inadequate water management. Insect damage was also negligible, but it was greater in the unprotected treatments; presumably, this could be due to the washing off of insecticides by rainfall.

Fruit-cracking was a problem with the large fruited cultivar. The unprotected bag and soil treatments exhibited serious fruit cracking in late August and early September because of a number of rainstorms. The bag treatments were more susceptible to cracking due to wider and more rapid variations in soil moisture content.

Unsalable 'other' yields were higher in the outside treatments, though not always significantly. The primary maladies for this category were sunburn, disease, small size, and bad fruit shape.

Table 15. Yield of two tomato cultivars growing in unprotected or rain-sheltered soil and bag culture.

Yield per Plant	Bag		Soil		LSD 5%
	rain-sheltered	unprotected	rain-sheltered	unprotected	
	Cv. 5915-206-2-2-0				
Grade 1 fruits (no.)	3.9	3.1	22.9	12.5	3.0
Grades 1 + 2 fruits (no.)	31.9	20.0	48.1	36.5	10.4
Grades 1 + 2 + salable offgrade (no.)	47.3	40.1	59.4	54.8	12.2
Blossom end rot (no.)	0.8	0.1	0.1	0.1	0.3
Cracked (no.)	4.5	8.6	0.4	3.8	2.6
Insect damage (no.)	0.6	1.5	0.7	2.0	1.5
Unsalable others[z] (no.)	2.1	5.3	3.8	9.3	4.5
Total unsalable fruits (no.)	8.0	15.5	5.0	15.2	4.7
Blossom end rot (wt in g)	24.0	5.0	2.0	1.0	11.0
Cracked (wt in g)	193.0	438.0	26.0	310.0	196.0
Insect damage (wt in g)	20.0	45.0	19.0	87.0	68.0
Unsalable others[z] (wt in g)	52.0	175.0	150.0	336.0	157.0
Total unsalable fruits (wt in g)	289.0	663.0	197.0	734.0	257.0
Green fruit (wt in g)	344.0	192.0	685.0	855.0	284.0
	Cv. 5915-533-D4-3-0				
Grade 1 fruits (no.)	28.4	42.3	67.4	57.7	20.7
Grades 1 + 2 fruits (no.)	76.5	68.3	81.9	79.3	15.7
Grades 1 + 2 + salable offgrade (no.)	90.5	82.6	92.0	94.0	15.9
Blossom end rot (no.)	15.2	5.5	3.7	0.7	4.6
Cracked (no.)	0.5	4.6	0.7	2.0	2.6
Insect damage (no.)	0.3	0.7	2.0	4.7	ns
Unsalable others[z] (no.)	4.9	6.8	5.3	7.4	3.5
Total unsalable fruits (no.)	20.9	17.6	11.7	14.8	9.9
Blossom end rot (wt in g)	263.0	89.0	83.0	16.0	102.0
Cracked (wt in g)	8.0	89.0	22.0	51.0	54.0
Insect damage (wt in g)	3.0	11.0	45.0	76.0	ns
Unsalable others[z] (wt in g)	34.0	97.0	107.0	141.0	79.0
Total unsalable fruits (wt in g)	308.0	286.0	257.0	284.0	187.0
Green fruit (wt in g)	173.0	101.0	333.0	208.0	180.0

[z]Maladies include sunburn, disease, small fruit size, and bad fruit shape

The total unsalable yields of the large-fruited cultivar were higher for unprotected treatments. However, the total unsalable yields were similar for all the treatments with the small-fruited cultivar.

Two months after transplanting, numerous plants, particularly those in bags, demonstrated interveinal chlorosis on upper leaves. Two foliar sprays of $ZnSO_4$, $CuSO_4$ plus a soluble, complete foliar fertilizer followed by frequent sprays of the foliar fertilizer largely reduced this symptom and promoted healthy and vigorous plant growth. In fact, it is theorized that frequent foliar fertilizer application helped to extend the growing season for a month beyond normal expectations.

Conclusion

Diseases greatly reduced tomato yields during the hot, rainy season. Yields and quality of two tomato cultivars were improved with a 0.8 m wide plastic covered rain shelter over the rows during this season. Although yields with the bag culture were significantly lower than those of plants in the soil, the method is promising and needs additional research.

Effects of Direct Seeding, Transplanting, and Igetagel on Tomato Field Establishment

Introduction

The advantages of transplanting include less seed used, less bird damage, easier weed control, more uniformity, less pesticide and water use, and better utilization of land because the crop is grown

for a shorter time. However, direct seeding is a simpler system and eliminates labor, facilities, and materials needed to raise and transplant seedlings.

In this connection, Igetagel, a hydrophilic compound, which can expand to hold 200 or more times its weight of water may have possible uses in seedling establishment. The objective of this study was to determine if yields are affected by direct seeding or transplanting and if the use of Igetagel has beneficial effects with either system.

Materials and Methods

Two trials with a processing tomato cultivar, CL 5915-153D$_1$-3-3, were seeded on 22 March and 19 July, transplanted on 23 April and 9 August and harvested from 20 June to 23 July (four harvests) and 9 October to 15 November (six harvests). Row spacing was 1.5 m and plant spacing was 40 cm.

Treatments included direct seeding with and without 2.5 g of Igetagel per planting hole, transplanting seedlings from polyethylene pots (4.5 cm bottom × 6.5 cm top × 7.5 cm height) containing media with and without 2% Igetagel, and transplanting from a flat with media containing 2% Igetagel. The experiment was arranged as a randomized complete block design with four replications.

Results and Discussion

Field germination of direct seeded treatments was much lower than that in pots and flats (Table 16). Seedling height at transplanting time was greatest in both experiments in the seedling flats. However, the differences among treatments were small in the first experiment, and thus, it was not surprising to find no yield differences there.

In the second experiment, seedling height at transplanting was greatest in the flats, followed by that of the polyethylene pot with and without Igetagel and the direct seeded treatments in that order (Table 16). However, salable yields for the polyethylene pot treatments were highest, but only the direct seeded treatment with Igetagel yielded significantly less marketable fruit. There were no significant total yield differences among treatments, since the direct seeded treatment with Igetagel had more green fruit than the other treatments.

It is likely that seedlings transplanted from flats undergo more transplant shock than container transplants because roots are broken in the process of removing seedlings from the flat. Thus, their larger size at transplanting did not translate into higher yields.

Moisture conditions in both the field and nursery were adequate in these experiments; and thus, it is not surprising that Igetagel did not cause yield increase. In fact, the addition of 2.5 g Igetagel per planting hole resulted in significantly lower yields in the second experiment.

Table 16. The effects of direct-seeding, transplanting, and Igetagel on tomato germination rate, seedling size, and yield in a spring trial and on seedling height and yield in a summer trial.[z]

Treatment	GR (%)	Sdlg Ht at T (cm)		M Yield (t/ha)		T Yield (t/ha)	
	sp	sp	su	sp	su	sp	su
Direct-seeding	38	7.4	7.1	13.8	18.3	20.7	24.1
Direct-seeding + 2.5 g Igetagel/ planting hole	41	7.9	7.0	11.8	15.7	19.2	22.4
PE pot[y]	97	8.3	11.7	13.9	19.7	22.9	24.7
PE pot with 2% Igetagel	98	8.6	13.2	12.8	19.8	20.1	23.6
Flat with 2% Igetagel[x]	100	9.9	15.5	14.1	18.7	22.6	23.3
LSD 5%	9	1.2	1.0	ns	3.5	ns	ns

[z]GR = germination rate; Sdlg Ht at T = seedling height at transplanting; M Yield = marketable yield; T Yield = total yield (marketable yield plus unmarketable plus green fruits). [y]Transplanted from polyethylene pots (4.5 cm bottom × 6.5 cm top × 7.5 cm height) containing media. [x]Transplanted from a flat with media containing 2% Igetagel.

Conclusion

Tomato stands may be field-established by either transplanting seedlings or direct-seeding. Direct-seeded tomatoes had a lower germination rate than those in flats and pots. There were no significant

yield differences among transplanted and normal direct seeded treatments. Yields were not affected by the addition of Igetagel to the container media but decreased when 2.5 g of the compound was added to the planting hole of direct-seeded tomatoes.

Effects of Banking and Staking on Processing Tomato

Introduction

Staking of fresh market tomatoes has been practiced in many areas to reduce diseases and increase harvesting efficiency. However, the low price of processing tomatoes inhibits growers from doing this unless there could be sizable yield gains.

Banking is a tillage operation where soil from a 15 cm high ridge between two rows of plants is plowed over to the ridges of the plants. This operation is usually made right after the first fertilizer side-dressing treatment, thus, burying the fertilizer and small weeds around the plants. However, in tomatoes banking reportedly increased southern blight in some cases. The objective of this experiment is to determine the effects of staking and banking on two processing tomato cultivars.

Materials and Methods

Cultivars CL 5915-153-D_1-3-3 and CL 5915-93-D_1-1-0 were transplanted at a spacing of 1.5 × 0.4 m. Total fertilizer application included 180-42-150 kg NPK/ha applied basally and side-dressed at three and six weeks after transplanting. The experiment was arranged in a split-split plot design with four replications.

The first experiment was transplanted on 2 April and harvested on 27 May, 10 June, and 21. Treatments included banking after the first fertilizer side dressing (two weeks after transplanting), staking with one bamboo pole per plant started two weeks after transplanting followed three weeks later with a plastic band placed 45 cm to each side of the bed at a 1 m height to support the side branches, and finally, the no-banking and no-staking treatments.

The second experiment was transplanted on 17 July and harvested four times from 20 September to 16 October. Because of wet weather, banking was delayed until 44 days after transplanting. The first staking operation with one tying was made 28 days after transplanting, but no additional tying was done until 50 days after transplanting, at which time the plastic band was also installed.

Results and Discussion

Marketable fruit size of CL 5915-153-D_1-3-3 was 31 and 21 g; and of CL 5915-93-D_1-1-0 it was 69 and 33 g for trials 1 and 2, respectively. Fruit size was not affected by banking or staking.

The incidence of southern blight was highly variable in the first trial. However, in the second trial the incidence was higher in the banking treatments (Table 17). For CL 5915-93-D_1-1-0, the banking-staking treatment had a lower incidence of this disease than the unstaked-banking treatment.

In the first experiment, the highest salable yields for both cultivars were obtained with the banking-staking treatments. These yields were significantly higher than that of banking alone and that of the unbanked or unstaked treatments. However, staking alone resulted in higher yields than the no-banking, no-staking treatment for CL 5915-153-D_1-3-3 but not for CL 5915-93-D_1-1-0.

In the second experiment, banking and staking operations were carried out late because of wet weather and wet soil conditions. Nevertheless, staking resulted in higher yields for both cultivars. However, banking reduced yields of CL 5915-153-D_4-3-3 but not of CL 5915-93-D_4-1-0.

Conclusion

Tomato growers need to know the consequences of banking and staking operations on processing tomatoes. Banking increased southern blight incidence on two tomato cultivars in one experiment. Banking did not increase yields; in fact, banking too late (44 days after transplanting) resulted in lower

yields for CL 5915-153-D_4-3-3. Staking resulted in higher yields either with or without banking in all but one case.

Table 17. Effects of banking and staking on marketable yield and southern blight incidence on two processing tomato cultivars.

Treatment	Marketable Yield (t/ha) trial 1	Marketable Yield (t/ha) trial 2	Southern Leaf Blight (% plants infected[z])
CL 5915-153-D_4-3-3			
Banking + staking[y]	23.3	9.5	12.5
Banking, no staking	14.5	6.1	11.5
No banking + staking	19.6	16.3	2.1
No banking, no staking	12.0	13.3	1.1
CL 5915-93-D_4-1-0			
Banking + staking	21.3	10.4	11.5
Banking, no staking	14.2	4.4	23.0
No banking + staking	13.3	7.8	3.2
No banking, no staking	13.8	4.6	2.1
LSD 5%	5.8	1.3	5.8

[z]Trial 2, one week before harvest. [y]In the first experiment staking and banking were done at two weeks after transplanting. In the second experiment banking and staking were done 44 and 28 days after transplanting, respectively, but additional tying was delayed until 50 days after transplanting.

Effect of Plant Spacing on Growth and Yield of Three Processing Tomato Cultivars

Introduction

Tomato growers need to consider the ramifications of plant and row spacing carefully. For example, too low a plant population causes lower yields, whereas very high populations are costly to establish and reportedly reduce fruit size. Wide spacings between rows facilitate cultural operations and are preferred by the growers, but plants usually grow most efficiently when planted at equidistant spacings. To further complicate matters, the effects of population on different cultivars are not the same.

The objective of this study was to determine the effects of different row and plant spacings on three processing tomato cultivars.

Materials and Methods

Three determinate processing tomato cultivars (Tainan No. 2, TM 103, and PT 862) were transplanted with spacings between rows of 1.0, 1.2, and 1.5 m and spacings between plants of 0.3, 0.4, and 0.5 m. Seedlings (27 days old) were transplanted on 9 October 1984 from flats. There were five biweekly harvests of salable and unsalable tomatoes from 11 December 1984, and green tomatoes were also picked during the final harvest. The experiment was arranged into a split-split plot design replicated twice with cultivars as the main plot, spacing between rows as the subplots, and spacing between plants as the sub subplots.

Results and Discussion

TM 103 produced the highest marketable yields followed by PT 862 and Tainan No. 2 (Table 18). Yields tended to decrease as the spacings between rows and plants increased; however, this was not true for the main-effect means of the 1.0- and 1.2-m row spacing for PT 862. Spacing between plants affected TM 103 the most and PT 862 the least. The lowest yields occurred at a 1.5-m row spacing × 0.5-m plant spacing. The highest yields occurred at a 1.2 m × 0.3 m spacing for PT 862 and at a 1.0 × 0.3 m spacing for the other two cultivars.

Table 18. Marketable yield of three tomato cultivars at three different row and plant spacings.[z]

Spacing between Rows (m)	Yields (t/ha) on the ff. Spacings between Plants (m)			
	0.3	0.4	0.5	mean
Tainan No 2				
1.0	44.4 a	40.4 ab	29.1 bcd	38.0 A
1.2	31.2 bcd	35.7 abc	26.0 cd	31.0 B
1.5	34.8 abc	25.2 cd	22.6 d	27.5 B
Mean	36.8 A	33.8 A	25.9 B	32.2 Z
TM 103				
1.0	60.6 a	49.9 ab	39.7 b	50.1 A
1.2	50.1 ab	46.3 ab	43.5 b	46.6 AB
1.5	48.3 ab	38.7 b	40.4 b	42.5 B
Mean	53.0 A	45.0 B	41.2 C	46 4 X
PT 862				
1.0	41.5 ab	42.1 ab	36.6 ab	40.1 A
1.2	45.6 a	42.7 ab	40.0 ab	42.8 A
1.5	35.9 ab	33.4 ab	31.1 b	33.5 B
Mean	41.0 A	39.4 A	35.9 A	38.8 Y

[z]Separation of sub subplot means within tables (lower case letters), subplot means within rows and columns (upper case letters), and main plot means (X, Y, Z) by Duncan's multiple range test, 5% level.

However, yields at all row spacings × 0.3 m plant spacing (except Tainan No. 2 at a 1.2-m row spacing) and the 1.0 and 1.2 m × 0.4 spacings were statistically similar to the highest yield for each cultivar. In addition, yields of PT 862 from the 1.5 m × 0.4 m, 1.0 m × 0.5 m, and 1.2 m × 0.5 m spacings were also statistically similar to the highest yield.

The 1.0 m row spacing resulted in 1.1 to 1.7 t/ha more unsalable fruit than the wider spacings, but spacing between plants did not affect unmarketable fruit.

The proportion of green fruit by weight varied between 7.6 and 9.8% for the main-effect treatments. Since the processing industry will likely adopt a standard technique of ripening fruits with ethephon in the future, data on the effects of spacing on total (marketable, nonmarketable, and green) fruit number, yield per plant, and total fruit size are presented in Fig. 6.

TM 103 yielded the highest total number of fruits. The number of fruits it produced at a 1.5 m × 0.5 m spacing was significantly greater than at all the other spacings; however, no significant differences were observed with 0.3 and 0.4 m plant spacings at all row spacings. For the other two cultivars, greater increases in fruit number were observed with wider plant spacings than with wider row spacings. The percentages of marketable, unmarketable, and green fruit number were 71, 11 and 18, respectively.

No clear response pattern of fruit size to these spacings was observed. However, fruit size of PT 862 was clearly larger than that of the other two cultivars. The average fruit weight of the marketable fruit was 12 g heavier than the total mixture which also included unmarketable and green fruits. This was largely due to the smaller size of the green fruits.

Since fruit size was not affected greatly by spacing, total yield (kg) per plant followed a pattern similar to total number of fruit per plant. Therefore, the yield per plant was greater at a 1.5 m × 0.5 m spacing than at all the other spacings for TM 103. For the other two cultivars, the weight per plant was greater at wider plant spacings, but wider row spacings had less effect. Marketable yield by weight represented 83% of the total yield per plant.

Since the increase in weight per plant with wider spacings was less than proportional to the additional space required, growers would be advised not to choose the widest spacing (1.5 m × 0.5 m). The widest acceptable spacings are 1.2 m × 0.4 m and 1.5 m × 0.3 m for Tainan No.2 and TM 103. Spacings of 1.2 m × 0.5 m and 1.5 m × 0.4 m did not give significantly lower yields than closer spacings for PT 862.

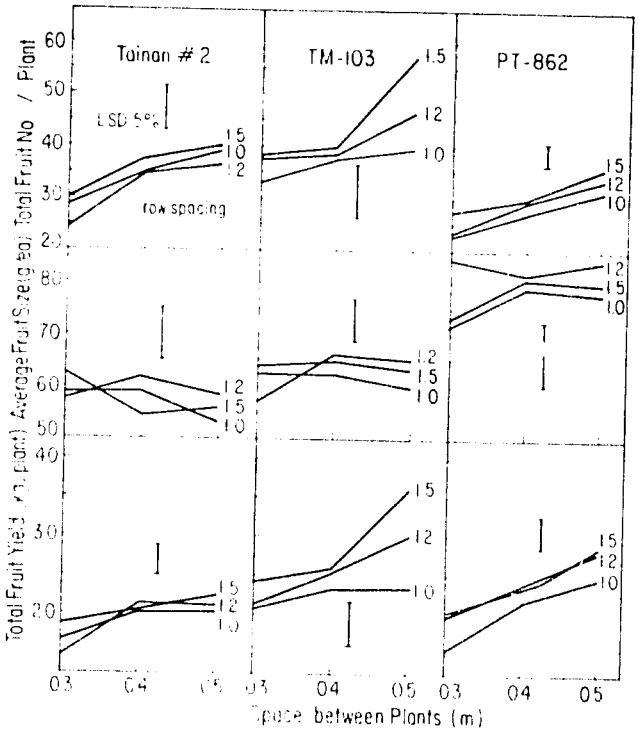

Fig. 6.
Average fruit size, total fruit number, and total fruit yield per plant of three processing tomato cultivars grown at different row and plant spacings.

Conclusion

Yield responses of processing tomato cultivars to plant and row spacings are expected, and these responses may vary with cultivars. No clear response pattern of fruit size was observed to the spacings ranging from 1.0 m × 0.3 m to 1.5 m × 0.5 m. Fruit number and weight per plant increased more with wider plant spacings than with wider row spacings, but the yield increases were less than proportional to the additional space required. PT 862 was least affected by spacing and only the widest spacing of 1.5 m × 0.5 m caused significantly lower yields. The widest acceptable spacings of TM 103 (the highest yielding) and Tainan No. 2 (the lowest yielding) were 1.2 m × 0.4 m and 1.5 m × 0.3 m.

Garden Program

World trends in food production and malnutrition suggest that even though food production is increasing in many developing nations, malnutrition is also increasing. In many instances malnutrition can be controlled if the malnourished in rural areas of these nations can learn to grow nutritious foods around their households. The AVRDC garden program is designed to raise the nutritional status of people in developing countries through research, development, training, and extension of various appropriate gardening technologies. Home, school, and market garden technologies have been developed at AVRDC over the last four years with nutritious and income-generating crops.

During the 1984-85 season AVRDC continued its gardening research and training at AVRDC. Three years ago the home gardening technologies were transferred to Thailand, which initiated a pilot garden project among small-farm families in a rural area 100 km from Bangkok. This year Thailand took over the project and extended it to five other provinces. Gardening has also been more extensively incorporated into the AVRDC training program with additional lectures and hands-on experiences for training scholars in the linkages between food, nutrition and agriculture. Finally, more research was initiated on a dryland garden that has the potential of producing greater yields while using less water.

AVRDC will continue to conduct gardening research and transfer the technologies and research results to areas of the world where such work can be of benefit. Plans have been laid to initiate in Indonesia and Bangladesh the same gardening activities that have been successful in Thailand. The 59 crops researched in the AVRDC garden program this year can go a long way toward raising the nutritional status and the quality of life in developing nations (Table 1).

School Garden

Introduction

Garden vegetables can provide a significant percentage of the micronutrients required by schoolchildren as they progress through stages of growth. A school garden could make nutritious vegetables available to the lunches of schoolchildren in developing nations, and it could also expose them to gardening and to the variety of tasty things that can be grown. This research aims to develop a school garden that contains an intercrop of culturally acceptable vegetables that will provide 1/2 cup of cooked vegetables (approximately 113 g) daily to at least 100 schoolchildren throughout the year.

Materials and Methods

Four seasonal gardens (Fig. 1) were planted from December 1984 through November 1985. Garden size was 10 x 18 m with twelve raised beds 10 m x 1.5 m x 25 cm. A commercial basal fertilizer was applied in the beginning of the year and composting was applied periodically thereafter. The choice of vegetables grown was based on cultural acceptability, seasonal adaptability, nutritional value, and easy management. Appropriate crop management procedures were employed, such as minimum use of pesticides, hand weeding, manual removal of insects, and the use of mosquito netting over the crop beds to control air-borne insects during the early stages of crop development.

Table 1. The 59 crops grown in the AVRDC gardens, 1984 to 1985.

Common Name	Scientific Name	Common Name	Scientific Name
1. Amaranth	*Amaranthus mangostanus* L.	32. Lettuce	*Lactuca sativa*
2. Basil	*Ocimum basilicum*	33. Malabar Spinach (Malabar-nightshade)	*Basella alba* L.
3. Bitter gourd (Balsam pear)	*Momordica charantia*	34. Malunggay	*Moringa oleifera*
4. Bottle gourd	*Lagenaria siceraria*	35. Mango	*Mangifera indica*
5. Broccoli	*Brassica oleracea* var. *italica*	36. Mungbean	*Vigna radiata*
6. Cabbage	*Brassica oleracea* var. *capitata*	37. Mustard	*Brassica juncea*
7. Carrot	*Daucus carota* var. *sativa*	38. Okra	*Hibiscus esculentus*
8. Cassava	*Manihot esculenta*	39. Pai-tsai	*Brassica campestris* Chin
9. Cauliflower	*Brassica oleracea* var. *botrytis*	40. Papaya	*Carica papaya*
10. Celery	*Apium graveolens*	41. Peanut	*Arachis hypogaea*
11. Chayote	*Sechium edule*	42. Pumpkin	*Curcurbita moschata*
12. Cherry radish	*Raphanus sativus*	43. Radish	*Raphanus sativus*
13. Chinese cabbage	*Brassica campestris* subsp. *pekinensis*	44. Rape green	*Brassica napus*
14. Chinese leek	*Allium odorum*	45. Shallot	*Allium ascalonicum*
15. Ching-chiang pai-tsai (spoon cabbage)	*Brassica campestris* var. *chinensis*	46. Snake gourd	*Trichosanthes cucumerina*
16. Coriander	*Coriandrum sativum*	47. Snap bean	*Phaseolus vulgaris* L.
17. Corn	*Zea mays*	48. Snow pea	*Pisum sativum*
18. Cowpea	*Vigna unguiculata* subsp. *unguiculata*	49. Spinach	*Spinacia oleracea*
19. Cucumber	*Cucumis sativus*	50. Sponge gourd	*Luffa cylindrica*
20. Eggplant	*Solanum melongena*	51. Sweet corn	*Zea mays* L.
21. Garland chrysanthemum	*Chrysanthemum coronarium*	52. Sweet pepper	*Capsicum annuum*
22. Garlic	*Allium sativum*	53. Sweet potato tips	*Ipomoea batatas*
23. Ginger	*Zingiber officinale*	54. Taro	*Colocasia esculenta*
24. Hot pepper (bird chillies, cherry capsicum)	*Capsicum frutescens*	55. Tomato	*Lycopersicon esculentum*
25. Hyacinth bean	*Dolichos lablab*	56. Vegetable soybean	*Glycine max*
26. Ipilipil	*Leucaena leucocephala*	57. Welsh onion	*Allium fistulosum*
27. Kale	*Brassica oleracea* var. *acephala*	58. Winged bean	*Psophocarpus tetragonolobus*
28. Kangkong (water convolvulus)	*Ipomoea aquatica*	59. Yard-long bean (asparagus bean, pea bean)	*Vigna unguicalata* var. *sesquipedalis*
29. Kohlrabi	*Brassica oleracea* var. *gongylodes*		
30. Leaf beet	*Beta vulgaris*		
31. Lemon grass (citronella grass, geronium grass)	*Cymbopogon citratus*		

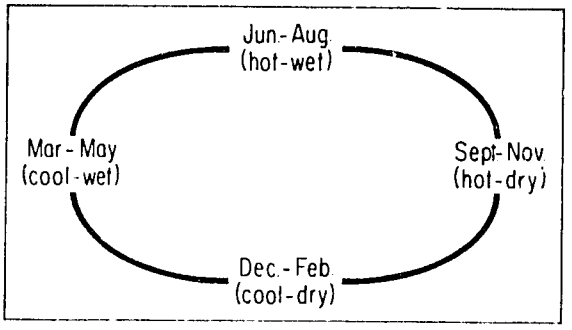

Fig. 1. Seasonal pattern of AVRDC gardens, Taiwan.

Edible yield was recorded for each vegetable in each planting period. The vegetables were also analyzed by AVRDC for their content of protein, calcium, iron, and Vitamins A and C. The amount that 1/2 cup of vegetables could contribute to the daily recommended dietary allowance (RDA) of a 10-year-old schoolchild was also calculated.

Results and Discussion

The yield and nutritional contribution of vegetables in a representative school garden (September to November) are shown in Table 2. During the year this garden produced daily yields ranging from 7.8 kg to 14.1 kg with an average of 11.1 kg. (Table 3). Heavy rains during the Garden III period reduced the average yield. Nevertheless, the school garden produced an average of 99 half-cup portions of nutritious vegetables daily throughout the year. Each half-cup portion could provide a schoolchild with significant percentages of his RDA for iron and Vitamins A and C (Table 4).

Table 2. Yield and nutrient contribution of School Garden IV, September to November 1985.

Crop	Edible Yield (kg)	Edible Yield/ Day (kg)	Times Harvested	Nutrient Yield/Day protein (g)	iron (mg)	calcium (mg)	Vit. A (μg.RE)	Vit. C (mg)
Amaranth	27.50	0.302	9	9.06	14.19	878.82	824.46	160.06
Bitter gourd	11.11	0.122	9	0.98	2.81	31.72	22.33	69.54
Broccoli	16.80	0.185	6	5.55	1.48	64.75	431.05	91.76
Cauliflower	11.70	0.129	8	3.35	1.42	49.02	8.64	65.40
Ching chiang	72.90	0.801	9	20.03	27.23	1666.08	3187.98	686.46
Eggplant	55.00	0.604	16	8.46	4.23	36.24	501.32	71.27
Kale	7.90	0.087	1	2.09	2.87	202.71	217.50	100.05
Kangkong	69.50	0.764	13	22.92	45.84	586.24	2498.28	366.72
Leaf beet	25.10	0.276	4	4.66	13.36	122.65	450.71	7.65
Lettuce	67.90	0.746	7	12.68	50.73	686.32	3334.62	179.04
Mustard	115.60	1.270	11	30.48	25.40	2260.60	4000.50	1447.80
Okra	59.80	0.657	20	10.12	13.47	707.13	76.67	52.17
Pai-tsai	151.05	1.660	19	29.88	79.68	2456.80	2954.80	1228.40
Radish	12.40	0.136	4	0.82	0.94	24.67	14.28	23.38
Rape green	109.40	1.202	12	25.24	69.72	1730.88	4964.26	575.76
Sponge gourd	84.98	0.934	34	4.76	3.74	59.12	114.88	99.66
Taro (head)	16.50	0.181	2	6.77	1.92	99.06	0	9.05
Taro (leaf)	2.10	0.023	1	0.87	0.64	47.36	183.62	22.62
Taro (stem)	5.20	0.057	1	0.74	0.88	146.38	19.00	5.09
Yard-long bean	21.50	0.236	9	6.61	4.25	120.36	78.59	66.08
Total	943.94	10.372	195	206.07	364.80	12276.91	23883.49	5327.96

Table 3. Contribution in selected nutrients of the AVRDC school garden, December 1984 through November 1985.

	Edible Yield/Day (kg)	Food Composition in Edible Yield/Day				
		protein (g)	iron (mg)	calcium (mg)	Vit.A (μg.RE)	Vit. C (mg)
Garden I	12.206	234.14	439.67	15614.69	36265.92	6963.35
Garden II	14.127	297.23	612.87	17677.10	45598.80	6539.22
Garden III	7.899	173.13	291.44	9039.50	17981.26	3472.93
Garden IV	10.372	206.07	364.80	12276.91	23883.49	5327.96
Average	11.151	227.64	427.20	13652.05	30932.37	5575.87

Table 4. Percentage of a 10-year-old child's RDA contained in 1/2 cup (113 g) of garden vegetables.[7]

	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (μg.RE)	Vitamin C (mg)
RDA for a 10-year-old	38.00	650.00	7.00	575.00	20.00
Contents in 1/2 cup vegetables	3.23	92.17	6.16	333.23	57.00
Contribution in 1/2 cup to the RDA of a 10-year-old (%)	8.50	29.56	88.00	57.95	285.00

[7]Source: Food and Agriculture Organization. 1974. Handbook on human nutritional requirements. FAO. Rome. In 1984-1985, the school garden produced 11.15 kg vegetables per day; this translates to 99 1/2 cup servings. RDA = recommended dietary allowance.

Conclusion

In the 1984-85 season the AVRDC school garden produced an average daily yield of over 11 kg of vegetables, enough half-cup portions for 99 schoolchildren. This type of technology is suitable for transfer to developing countries where children from low-income families can be provided with nutritious vegetables to augment their rice-box lunches at school.

Home Garden

Introduction

The AVRDC home gardens are designed to contain an intercrop of nutritious vegetables (and a few fruits) that are culturally acceptable to people in selected developing countries and provide a family of five (two adults and three children) with reasonable percentages of their daily recommended dietary allowance (RDA) for calcium, iron, Vitamins A and C, plus measurable amounts of protein which is generally not expected to be significant. However, the protein quality from dark, green leafy vegetables is very good and its addition in the diet can increase the bioavailability of protein from other sources such as grains and legumes.

Home gardens have been developed at AVRDC for Indonesia, the Philippines and Thailand. A Vitamin-A garden has been developed to demonstrate how much of this nutrient (deficient in diets of many people in the developing world) can be produced in a small garden of culturally acceptable plants. An urban garden was also researched to see if adequate yields can be obtained from vegetables growing in boxes and pots.

Materials and Methods

In the Vitamin-A, Philippines, Thailand, and Indonesia gardens, a culturally acceptable intercrop of vegetables and a few fruits were planted in 4 x 4.5 m plots consisting of three raised beds (4 m x 1.5 m x 25 cm) per plot. Herbs, spices, and climbing vegetables were planted around the edges of garden beds as fence crops. Each type of home garden was planted four times during the year in response to the slight seasonal changes in the AVRDC environment.

Low-input and appropriate agricultural procedures were practiced in all gardens, such as hand-weeding, manual insect removal, rice-straw mulch, and a mosquito-net screening during the early stages of growth to protect plants from air-borne insects.

During the seasonal growing periods, data were collected on the yield of each crop in each garden; samples of each crop were analyzed for content of the five selected nutrients: protein, calcium, iron, and Vitamins A and C. The RDA for a family of five was obtained from literature (Table 5); and from these data, the percentage of RDA available for a family of five was determined for each crop and garden.

Table 5. Recommended dietary allowance (RDA) for a family of five (two adults and three children, ages 1 to 12).[7]

	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (μg.RE)	Vitamin C (mg)
Father	37	450	7	750	30
Pregnant mother	38	1100	21	750	50
Child (age 1 to 3)	16	450	7	250	20
Child (age 4 to 6)	20	450	7	300	20
Child (age 10 to 12)	38	650	7	575	20
Total	149	3100	49	2625	140

[7]Source: Food and Agriculture Organization. 1974. Handbook on human nutritional requirements. FAO, Rome.

Results and Discussion

The yield and nutritional composition of the crops grown in a representative home (Thailand) and Vitamin A (December to February) gardens are shown in Tables 6 and 7, respectively. The mean contribution from four seasons of each type of garden is summarized in Table 8. The output of all the gardens in all seasons (June to September) was adequate. Daily harvests were purposely kept between 0.8 kg and 1.2 kg to provide reasonable yields and still be able to use slow reacting compost as a fertilizer medium. Nutritional contribution of each garden to the RDA of a family of five was very good for iron and Vitamins A and C, and reasonable for calcium and protein.

Conclusion

The yields and nutritional outputs for 1984-85 reflect the value of a small home garden to a family of five in a developing country. An impressive amount of selected nutrients were consistently produced by these gardens throughout the year.

Urban Garden

Introduction

Population shifts toward more urbanization in developing countries means a greater demand for agricultural products in cities and towns. As demand for such items as fresh vegetables increases, so often will the prices, thus, making it difficult for low-income urban dwellers to afford them. If these people can grow some of their own vegetables in containers, then a ready supply could be made

available. This study was conducted to determine which types of garden vegetables will grow in containers and how much of daily yields they will produce.

Materials and Methods

A selection of short-root vegetables were planted in eight wooden boxes, 115 × 35 × 15 cm. The area of each box was 0.4 m^2 or a 3.2 m total. Boxes were stacked in step-wise fashion on a metal frame to receive equal and maximum sunlight and take up a minimum of ground space. Crops were replanted after each harvest, with each box planted five to eight times during the year. Compost was used as fertilizer. Insects and weeds were removed by hand. A few climbing vegetables were also grown in pots around the group of boxes.

Results and Discussion

The yields and nutritional output of the crops grown in a representative urban garden (September to November) is shown in Table 9. The urban home garden produced an average of 0.22 kg per day of nutritious vegetables, with 244 harvests during the year. The nutritional contribution to the daily recommended dietary allowance (RDA) of a family of five is not significant in any nutrient, except in Vitamin C (Table 8). Though the yields were not impressive compared to a 4 × 4 m home garden they do provide something for the urban poor.

Conclusion

An urban garden growing nutritious vegetables in eight wooden boxes totalling 3.2 m^2 in area was studied. Yields and nutritional outputs were recorded. Results showed that this type of garden can yield 0.22 kg of nutritious vegetables daily, with 244 harvests throughout the year.

Market Garden

Introduction

As urban populations increase in developing countries, and the demand for vegetables becomes greater, peri-urban areas (rural areas that surround urban centers) could be put into use by producing some of the vegetables. Small market gardens, such as the type seen all over Taiwan, could produce the vegetables on a daily basis to meet urban demand. This study aimed to develop a garden that can be grown by the rural poor in peri-urban areas that will produce enough cash after costs to increase a family's income significantly by 30%.

Materials and Methods

Market prices published monthly for selected vegetables during the previous year were analyzed to see which vegetables might command a good price. The most promising of these were grown in a 10 × 20 m plot consisting of 13 raised beds (10 m × 1.5 m × 25 cm). Low-input management procedures were practiced (e.g., minimum use of pesticides and commercial fertilizers). At harvest time the vegetables were sold wholesale at local markets. The yield of each vegetable in each seasonal garden, the corresponding wholesale market price, and the gross monetary return per kilogram were recorded for the year.

Table 6. Yield and nutrient contribution of Thailand Home Garden III. June 1985 to August 1985.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg.RE)	Vitamin C (mg)
1	Basil	92	2.65	0.029	3	0.96	1.39	92.80	217.50	7.83
	Lemon grass	92	33.6	0.365	17	6.42	16.83	424.97	511.0	76.21
2	Rape green	28	2.25	0.024	3	0.50	1.39	34.56	99.12	11.50
	Amaranth	66	1.67	0.018	4	0.54	0.85	52.38	49.14	9.54
3	Lettuce	32	2.85	0.031	4	0.53	2.11	28.52	138.57	7.44
	Pai-tsai	3	1.0	0.011	1	0.20	0.53	16.28	19.58	8.14
	Rape green	34	2.05	0.022	3	0.46	1.29	31.68	90.86	10.54
4	Mustard	52	3.51	0.038	4	0.91	0.76	67.64	119.0	43.32
	Kangkong	65	1.38	0.015	3	0.45	0.90	17.40	49.05	7.20
5	Amaranth	62	5.08	0.055	7	1.65	25.85	160.05	150.15	29.15
6	Broccoli	2	1.5	0.016	1	0.48	0.13	5.60	37.28	7.94
	Pai-tsai	77	1.22	0.013	4	0.23	0.32	19.24	23.14	9.62
7	Kangkong	19	2.4	0.026	3	0.78	1.56	30.16	85.02	12.48
	Mustard	79	2.35	0.026	4	0.62	0.52	46.28	81.90	29.64
8	Eggplant	54	8.2	0.089	14	1.25	0.62	5.34	73.87	10.50
9	Lettuce	20	2.8	0.030	4	0.51	2.04	27.60	134.10	7.20
	Ching chiang	70	1.53	0.017	3	0.43	0.58	35.36	67.66	14.57
Fence:										
	Tomato	92	1.25	0.014	2	0.13	0.07	2.38	15.54	3.28
	Ipilipil	92	20.7	0.225	6	15.05	16.38	125.17	1593.00	113.87
	Taro (tuber)	92	3.1	0.034	1	1.27	0.36	18.61	0	1.70
	Sweet potato tips	92	2.3	0.025	2	1.00	2.86	34.43	31.25	11.84
	Cucumber	92	2.95	0.032	5	0.13	0.10	4.48	0.80	2.21
	Welsh onion	92	0.7	0.008	1	0.12	0.10	6.90	25.86	3.09
	Basil	92	0.43	0.005	1	0.17	0.24	16.00	37.50	1.35
	Yard-long bean	92	0.55	0.006	3	0.17	0.11	3.06	2.00	1.68
Total			108.02	1.174	103	34.96	78.18	1306.89	3653.59	441.84
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
Percentage of RDA contributed by garden						23.47	159.56	42.16	139.19	315.60

Table 7. Yield and nutrient contribution of Vitamin A Home Garden I, December 1984 to February 1985, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg.RE)	Vitamin C (mg)
1	Spinach	12	1.77	.020	3	.52	.60	18.20	108.60	8.26
	Lettuce	70	8.61	.096	3	1.63	6.53	88.32	429.12	23.04
2	Pai-tsai	57	8.81	.098	12	1.76	4.70	145.04	174.44	72.52
	Lettuce	56	2.00	.022	4	.37	1.50	20.24	98.34	5.28
	Mustard	27	1.40	.016	1	.38	.32	28.48	50.40	18.24
3	Ching chiang	34	10.55	.117	11	2.93	3.98	243.36	465.66	100.27
	Garland chrysanthemum	22	.36	.004	1	.06	.11	3.04	17.52	.68
4	Lettuce	12	.65	.007	2	.12	.48	6.44	31.29	1.68
	Rape green	24	3.77	.042	4	.88	2.44	60.48	173.46	20.12
	Garland chrysanthemum	58	3.18	.035	3	.53	.95	26.60	153.30	5.92
5	Lettuce	41	.91	.010	3	.17	.68	9.20	44.70	2.40
	Mustard	42	11.70	.130	19	3.12	2.60	231.40	409.50	148.20
	Pai-tsai	71	5.29	.059	4	1.06	2.83	87.32	105.02	43.66
6	Lettuce	5	1.26	.014	2	.24	.95	12.88	62.58	3.36
	Cherry radish	73	5.24	.058	6	.58	.23	15.66	0	24.36
	Carrot	90	1.00	.011	1	.11	.23	3.96	178.97	1.13
7	Mustard	67	9.84	.109	10	2.62	2.18	194.02	343.35	124.26
	Garland chrysanthemum	61	2.48	.028	4	.42	.76	21.28	122.64	4.73
8	Pai-tsai	59	9.81	.109	7	1.96	5.23	161.32	194.02	80.66
Fence:										
	Snap bean	56	.74	.008	7	.25	.10	2.40	2.40	2.24
	Pumpkin	62	3.52	.039	3	.23	.28	1.28	152.10	2.12
	Taro (tuber)	90	1.14	.013	1	.49	.14	7.11	0	.65
	Kohlrabi	49	1.34	.015	3	.39	.20	7.80	50.00	10.20
Total			95.37	1.060	114	20.82	38.02	1395.83	3367.41	703.98
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
Percentage of RDA contributed by garden						13.98	77.60	45.03	128.29	502.85

Table 8. Results from four AVRDC Home Gardens means over four seasons, December 1984 through November 1985.

	Yield/Day (kg)	Percentage of Contribution to RDA[z] of a Family of Five				
		protein	iron	calcium	vitamin A	Vitamin C
Indonesia garden	1.02	14.40	92.42	39.00	106.65	322.42
Thailand garden	1.20	20.26	108.71	39.76	128.81	376.43
Philippine garden	1.11	16.21	82.72	38.72	100.64	377.83
Vitamin A garden	0.99	14.35	73.89	41.04	107.50	391.07
Urban home garden	0.22	3.35	18.65	9.68	27.60	93.16

[z]Recommended dietary allowance

Results and Discussion

A summary of all four seasonal gardens showed that the garden produced 1,865 kg of market-quality vegetables (Table 10). These sold at the wholesale market price of NT$18,366 (US$459). Deducting cash costs (seeds, fertilizer, and pesticide) of NT$1,508 (US$37.70), the market garden made a net profit (or "return to labor") of NT$16,858 (US$423). Labor costs are not included under the assumption that many household members in peri-urban areas of developing countries are unemployed, and they will supply the labor. Results show that the market garden can increase the annual income of a peri-urban family by more than 30%. This percentage could be increased by selling the produce directly to the consumer, instead of to wholesalers as in the case of the AVRDC market garden.

Conclusion

The market garden produced 1,865 kg of market quality vegetables during the year. Deducting cash costs, the garden produced a wholesale profit of US$423, a figure that could readily increase the income of peri-urban families in developing countries who may produce a yearly household income of US$1,000.

Permanent Composting Beds for Dryland Gardening in the Tropics

Introduction

Dr. Chris Stearn, former AVRDC soil microbiologist, conducted feasibility tests on the use of permanent composting beds in home gardens as a way of producing good yields with less water than is normally required in a home garden. These beds consist of layers of organic material that have different carbon to nitrogen ratios (C:N) for each bed. The expected result is a steady release of plant nutrients over a growing season, thus, resulting in maximum yield.

Because the composting beds are initially high (25-30 cm) they have good water-retention capabilities. These beds are constructed once and then they can be maintained with the addition of household organic waste and small amounts of water as needed. This study was conducted to compare yield and water use between permanent composting and sunken beds. Sunken beds are normally used in the dry season as a technique to retain water. They are essentially flat beds with raised sides to keep water from running off.

Materials and Methods

Four 1.8 x 2 m plots were constructed, two for composting beds and two for sunken beds to use as check plots. The plots were constructed in a controlled environment consisting of a translucent plastic roof over a raised area, with plastic sheeting laid over the area before 1 m of dirt was added to raise the beds well above the normally high water table at AVRDC. The four plots were built on

Table 9. Yield and nutrient contribution of Urban Home Garden IV, September 1985 to November 1985.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg.RE)	Vitamin C (mg)
1	Amaranth	6	0.34	0.004	2	0.12	0.19	11.64	10.92	2.12
	Ching chiang	47	1.55	0.017	4	0.43	0.58	35.36	67.66	14.57
2	Mustard	41	1.44	0.016	3	0.38	0.32	28.48	50.40	18.24
	Rape green	35	2.57	0.028	4	0.59	1.62	40.32	115.64	13.41
3	Ching chiang	4	0.31	0.003	3	0.08	0.10	6.24	11.94	2.57
	Rape green	34	1.12	0.01[illegible]	3	0.25	0.70	17.28	49.56	5.75
	Kale	52	1.20	0.01[illegible]	2	0.31	0.43	30.29	32.50	14.95
4	Lettuce	24	0.43	0.00[illegible]	1	0.09	0.34	4.60	22.35	1.20
	Rape green	39	3.01	0.033	5	0.69	1.91	47.52	136.29	15.81
5	Kangkong	32	0.82	0.009	2	0.27	0.54	10.44	29.43	4.32
	Mustard	55	2.57	0.028	4	0.67	0.56	49.84	88.20	31.92
6	Kale	19	0.46	0.005	3	0.12	0.17	11.65	12.50	5.75
	Pai-tsai	49	2.09	0.023	4	0.41	1.10	34.04	40.94	17.02
7	Chinese leek	91	1.55	0.017	4	0.51	0.37	14.79	73.61	5.95
8	Pai-tsai	13	0.99	0.011	3	0.20	0.53	16.28	19.58	8.14
	Amaranth	41	0.77	0.008	2	0.24	0.38	23.28	21.84	4.24
	Pai-tsai	37	1.10	0.012	1	0.22	0.58	17.76	21.36	8.88
Plots:										
	Yard-long bean	39	2.03	0.022	10	0.62	0.40	11.22	7.33	6.16
	Sweet pepper	10	0.11	0.001	1	0.01	0.01	0.12	2.92	1.03
	Broccoli	80	3.78	0.042	4	1.26	0.34	14.70	57.86	20.83
Underframe:										
	Pai-tsai	37	1.15	0.013	2	0.23	0.62	19.24	23.14	9.62
Total			29.39	0.322	67	7.70	11.79	445.09	935.97	212.48
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
Percentage of RDA contributed by garden						5.17	24.06	14.36	35.66	151.77

this raised area with trenches, 1 m deep, to separate the four plots. In this manner, rain, groundwater, and interactive effects between plots were controlled.

Table 10. Yield and profit of AVRDC Market Gardens, December 1984 through November 1985.

	Marketable Yield (kg)	Wholesale Market Price (NT$)	Cash Cost[7] (NT$)	Profit (NT$)
Garden I	449.4	4185	391	3794
Garden II	457.6	3281	506	2775
Garden III	551.8	4074	404	3670
Garden IV	407	6826	207	6619
Total	1865.8	18366	1508	16858
Net wholesale profit (US$)				(US$423)

[7]Cash cost includes the cost of seeds, pesticide, and chemical fertilizer

Table 11. Analysis of raw materials and C:N ratio by layer.

Material	Dry Wt (kg)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Org. Matter (%)	C:N Ratio
Bottom Layer						
Rock phosphate	0.89	0.01	0.001	0.002	0.30	7250.00
Corn cob (coarse)	3.18	0.34	0.12	0.06	55.86	95.29
Chicken manure	9.88	2.69	7.18	2.22	35.71	21.56
Palm leaves	1.80	0.79	0.27	0.29	75.00	58.22
Straw	2.43	0.57	0.31	1.89	64.20	101.58
Banana leaves	1.05	1.18	0.62	2.35	72.21	35.64
Straw	2.43	0.57	0.31	1.89	64.20	101.58
Sub total	21.66		Layer C:N Ratio			34.71
Middle Layer						
Straw	2.43	0.57	0.31	1.89	64.20	101.58
Dry leaves	2.34	1.40	0.25	0.42	57.90	41.46
Bagasse	3.70	1.26	1.38	8.65	20.70	13.46
Corn cob (fine)	2.98	0.43	0.17	0.29	61.91	83.51
Chicken manure	12.95	2.69	7.18	2.22	35.71	21.56
Mushroom compost	10.01	0.67	0.40	0.53	16.50	86.05
Peanut hull	3.90	0.87	0.13	0.42	54.60	66.97
Sub total	38.31		Layer C:N Ratio			35.71
Top Layer						
Peanut hull	3.90	0.87	0.13	0.42	54.60	66.97
Corn cob (fine)	2.69	0.43	0.17	0.29	61.91	83.51
Soybean trash	2.65	0.82	0.25	0.93	64.20	71.17
Rice hull	9.77	0.40	0.11	0.23	59.10	143.56
Sub total	19.01		Layer C:N Ratio			97.77
Total	78.98					

A variety of garden vegetables was planted in both the composting and sunken beds. The variety consisted of eggplant, sweet potato (for tips), two types of lettuce, cherry radish, tomato, amaranth, and sweet corn.

The composting beds received a selected assortment of plant refuse available in the AVRDC environment. The material was placed on each composting bed in three layers totalling 25 cm high. The materials used in each layer and their C:N ratios are shown in Table 11. Small amounts of water were applied to the sunken beds on a daily basis, which is the usual garden watering practice in the tropics. Composting beds were watered once after they were built, and then watered only when the plants showed a need. Data were collected over a three month period.

Results and Discussion

Yields of all vegetables, except eggplant, was greater from the composting beds than from the sunken beds (Table 12). Less than half the water was required by the composting beds. This preliminary trial resulted in more yield from less water with the composting method. The results are encouraging and the trial will be extended to a full year agricultural cycle in 1986.

Conclusion

The composting beds produced greater yields with less than half the amount of water used in the sunken beds. The results from the three month trial were encouraging, and the experiment will be continued for a full year's agricultural cycle.

Table 12. Summary of yield and water use in the permanent composting and sunken beds.

Crop	Yield of Ck (kg)	Yield of Com. post (kg)
Eggplant	3.30	2.15
Sweet potato tips	1.52	3.50
Lettuce (curly)	0.38	0.83
Cherry radish	0.40	0.52
Tomato	6.73	9.54
Lettuce (native)	0.12	0.30
Amaranth	1.71	2.30
Corn	0.70	0.81
Total	14.86	19.95
Water used (liters)	1,275.00	550.00

Garden Pilot Project in Thailand

Introduction

In 1983 the Asia Bureau of the U.S. Agency for International Development (AID) requested and funded a pilot project to transfer the AVRDC gardening technologies to the rural families of Thailand. The garden technologies were first established and tested at AVRDC's Thailand Outreach Program (AVRDC TOP). At the same time an agreement was drawn up between AVRDC and Kasetsart University, Bangkok for Kasetsart to do the actual work, with financial support, direction, suggestions, and monitoring supplied by AVRDC under the AID funds.

Kasetsart tested the AID suggested methodology, Farming Family Living Systems (F-FLS) on the AVRDC TOP gardens and used it in collecting baseline data among 30 small family farming systems in the Bangpae subdistrict, 100 km southwest of Bangkok. Both the gardens and F-FLS were adjusted to Thai conditions, and the gardening technologies were established among 15 families in Bangpae and assessed by the F-FLS methodology. An additional 15 families without gardens were also included in the pilot project for comparison. Other Bangpae farm families eventually adopted the gardening technologies.

F-FLS is a microeconomics methodology that collects income e[illegible] arriable costs (cash and noncash costs) data on the various subsystems (i.e., cropping, livesto[illegible] household) in the small-family farming systems. Since gardening is considered a household a[illegible]vity (done mostly by family women and children), it was thought that a methodology which includes the activities of the household subsystem would be appropriate.

The overall goal of the pilot project is to assist Kasetsart University increase its institutional capabilities to conduct the necessary interdisciplinary research, development, training, and extension

on nutrition-related gardens; so that, Kasetsart can take the lead in national projects for the rural poor in Thailand.

Objectives

To help reach its goal the pilot project was broken down into four phases, each with its own objectives.

Phase I, April 1983 to March 1984

1. To qualitatively study the general economic and social factors of small family-farming systems in the Bangpae district of Ratchaburi Province.
2. To analyze the present vegetable production system and home gardening practices for selected pilot farms in Bangpae.
3. To comparatively evaluate the factor input, product output, yield, and cost of vegetable planting in the test gardens at AVRDC/TOP.

Phase II, May December, 1984

1. To study the patterns of consumption, buying behavior, and farm family expenses on vegetables in Bangpae.
2. To transfer the technologies of the AVRDC home garden system and appropriate assessment methodology from AVRDC/TOP to the 15 pilot study farms in Bangpae.
3. To demonstrate the feasibility of the recommended gardens under local existing conditions and gather daily data for an economic analysis.
4. To evaluate the home garden cropping system under the suggested F/FLS methodology and adjust the methodology as needed.
5. To collect and analyze nutritional data from 92 farm families in Bangpae regarding food-buying behavior, composition of foods consumed, nutrient output of gardens, and relative nutrient cost of garden vegetables.

Phase III, January June, 1985

1. To continuously transfer the AVRDC garden technologies and F/FLS methodology for one complete yearly agricultural cycle with emphasis on vegetable-cropping patterns sufficient for daily home consumption.
2. To study the socioeconomic factors that affect the farm family's confidence in their home gardens, and their degree of technology absorption and adoption.
3. To assess the nutritional impact of the gardens with biochemical, anthropometric, and clinical methods, and relative nutrient cost.

Phase IV, July December, 1985

1. To write a summary analysis of the transfer of gardening technologies to Bangpae, including analyses on gardening, F/FLS, and nutrition.
2. To write a training guide for Thai agricultural extension agents to use when introducing gardening technologies throughout the nation. The training guide will cover horticulture, nutrition, consumption, assessment, and extension.
3. To conduct a workshop for Thai extension agents to test the training guide prior to its use in the field.

Materials and Methods

A culturally-acceptable intercrop of garden vegetables was seasonally planted in 4 x 4.5 m plots consisting of three raised beds per plot (4 m x 1.5 m x 25 cm). Herbs, spices, and climbing vegetables

were planted as fence crops. Whenever possible, appropriate low-cost crop management was practiced such as hand-weeding, hand-removal of insects, the use of rice-straw mulch, and application of compost as fertilizer.

The gardens were planted and tested at AVRDC/TOP during Phase I, and baseline data were collected on farm-families in Bangpae. F/FLS was also tested on gardens at AVRDC/TOP.

In Phase II, 15 small-family farming systems were randomly selected and requested to set up AVRDC gardens. A demonstration garden was established by the Kasetsart staff to assist the families. The F/FLS methodology was further modified and simplified for use in Bangpae. Nutritional baseline data were also collected on the 15 gardening families, as well as on 77 other families in Bangpae. Socioeconomic data were also collected on farmers' attitudes and practices through a structured interview technique.

In Phase III the AVRDC gardens were continued among the 15 farm families. A daily record-keeping book was designed for use by farm families, with details to include activities conducted, factor inputs applied, and daily problems. In addition, a questionnaire was developed and administered to seven Bangpae vegetable retailers on the effect of home gardens on their daily vegetable sales. At the end of Phase III another socioeconomic survey was conducted on Bangpae gardeners' attitudes toward the demonstrated cropping system, their interest in home gardens, and their ability to absorb the new technology. The F/FLS methodology was also further simplified.

During Phase III the Kasetsart research staff (horticulturists, agricultural economists, nutritionists, and extension agents) visited all gardening families at least once each week to demonstrate methods of planting, disease and insect control, cultivation, fertilization, and data collection. The families were also shown how to incorporate garden yields into traditional dishes.

Phase III data were analyzed using F/FLS and the relative nutrient cost (RNC) methodologies. RNC analyzes the quotient between production costs of 100 g of a particular nutrient from a selected garden crop and the amount of the particular nutrient in 100 g of the crop.

As of this writing, Phase IV data are still being collected and analyzed. A tentative version of the training guide was written (in Thai) to teach agricultural extension agents about gardening, nutrition, assessment, and extension. The guide was tested in a three day Bangkok workshop sponsored by UNICEF and modified by the staff from Kasetsart University and the Thai Department of Agricultural Extension.

Results and Discussion

Phase I. Garden cropping patterns suitable for Bangpae were developed at AVRDC/TOP. These included such crops as cucumber, loofah, wax gourd, yard long bean, green onion, leaf amaranth and water convolvulus, eggplant, okra, garlic, and tomatoes. F/FLS economic analysis on these crops (cost, yield, and profit per crop cycle, per kg, per month) suggested they would be a suitable starting pattern for the Bangpae families.

Initial socioeconomic surveys among Bangpae farmers indicated they might readily accept gardening. The survey showed that:

1. Almost 90% liked vegetables.
2. Half of a family's food expenditure is on vegetables.
3. Average family size is five (just the size for which the 4 x 4 m AVRDC garden was designed).
4. A major constraint was growing intensively intercropped vegetables.

The initial use of F/FLS among the families showed some gaps in the methodology, such as in information on the nutritional impact of the gardens. However, the results on the AVRDC/TOP gardens and the Bangpae survey, both using F/FLS, showed that there were no major constraints in introducing gardens and a particular cropping pattern to Bangpae residents. In Phase II the methodology will be modified to cover the gaps.

Phase II. Two different cropping patterns were introduced into the 15 family farming systems (Figs. 2 and 3). Each cropping pattern resulted in approximately two months of harvests. Four months of available vegetables from their backyards encouraged the farmers to accept both cropping patterns. In addition, the 15 families found that they could now grow their own vegetables cheaply and have money left for other foods.

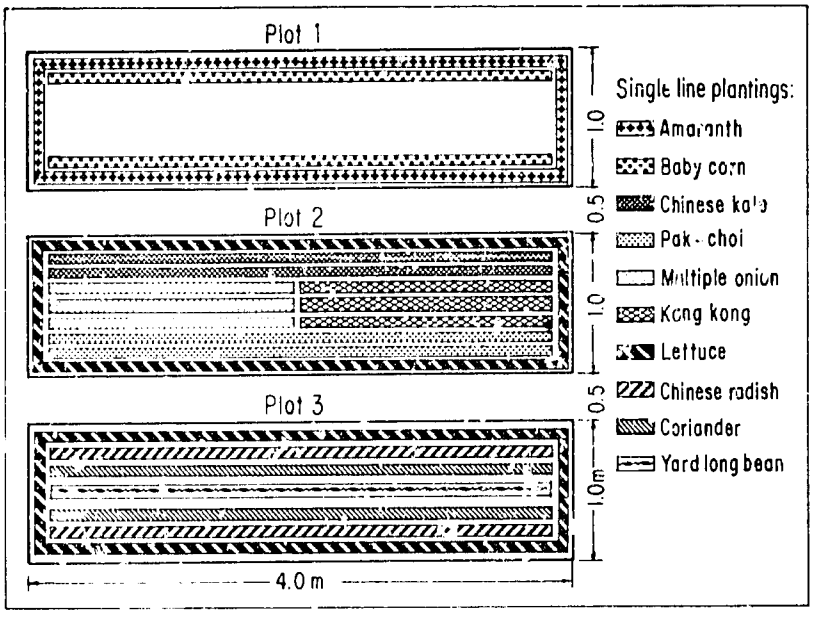

Fig. 2. Cropping systems in the home garden, crop 1.

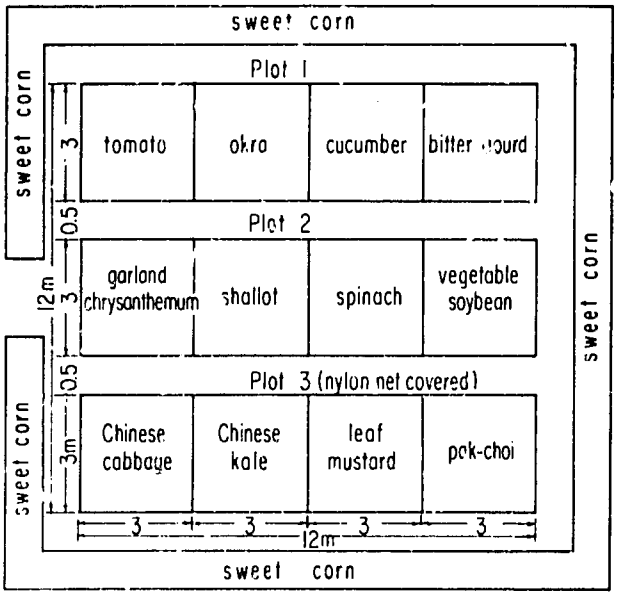

Fig. 3. Cropping systems in the home garden.

Problems expressed by the families dealt with disease and pest control, soil fertility, and stray animals. Nevertheless, three-fourths of the local farmers in the same districts as the 15 gardening families are now greatly interested in the AVRDC home gardens. Most of the 15 families spend some time describing and explaining their gardens to interested neighbors who want to start similar gardens.

A comparison between time spent on a home garden versus time spent on round trips to the market for a family without gardens showed that garden work takes less than one hour per day, while round trips to the market to buy vegetables takes about half an hour. A modified F/FLS showed that farm

families with home gardens consumed more nutritious vegetables and spent less money on food than did farm families without gardens.

The study also showed that the gardens demonstrated a more efficient use of time, with possibility of expanding to grow crops for sale (e.g., baby corn).

Phase III. In this phase seventeen varieties of garden vegetables were grown in two crop cycles (Table 13). The gardens produced satifactory yields and provided the families with significant protein, calcium, iron, and Vitamins A and C.

Table 13. Vegetables used in Phase III.

Scientific Name	Common English Name
1) *Brassica pekinensis*	Chinese cabbage
2) *Brassica juncea* var. *rugosa* (Roxb.)	Leaf mustard (taai kaai ts'oi)
3) *Brassica chinensis* var. *parachinensis*	Pakchoi sum (Green kuang futsoi)
4) *Brassica oleracea* var. *gongylodes* (L.)	Kohlrabi
5) *Brassica chinensis* var. *chinensis*	Green paak ts'oi
6) *Brassica juncea*	Mustard green (Choon Choy)
7) *Raphanus sativus* var. *longipinnatus*	Chinese radish
8) *Brassica pekinensis*	Pai-tsai (Speedy)
9) *Brassica albogiabra* (Bailey)	Kailaan (Chinese kale)
10) *Allium ascalonicum*	Spring onion
11) *Coriandrum sativum*	Coriander
12) *Daucus carota*	Carrot
13) *Capsicum frutescens*	Hot pepper
14) *Lycopersicon esculentum*	Tomato
15) *Zea mays* var *rugosa*	Sweet corn
16) *Vigna sinensis* var. *sesquipedalis*	Yard-long bean
17) *Lactuca sativa*	Lettuce
18) *Amaranthus gangeticus*	Amaranth
19) *Glycine max*	Vegetable soybean

The seventeen garden crops had variable production costs and nutritional outputs. Ideally, a home garden should have low production cost and high nutritional output. The RNC methodology showed which crops had a low relative nutrient cost for protein, calcium, iron, and Vitamins A and C (Table 14). The dark-green, leafy vegetables had the lowest RNC and are highly recommended for gardens in developing countries.

Table 14. Relative nutrient cost of the Bangpae home garden.

Crops	Production Cost (B/kg)	Edible Yield (kg)	Relative Nutrient Cost[7]					
			Energy (B/100 Cal)	Protein (B/g)	Ca (B/100 mg)	Fe (B/mg)	A (b/100 IU)	C (B/100 mg)
Sweet corn	4.90	3.64	.26	.10	12.25	1.23	1.10	4.90
Pai-tsai	4.00	1.65	2.22	.24	.33	.31	1.10	.93
Pakchoi	1.48	1.45	.62	.06	.08	.06	.07	.37
Yard-long bean	4.83	5.15	1.27	.17	1.15	.54	.85	2.20
Lettuce	3.85	1.12	1.93	.24	.47	.10	.08	2.27
Amaranth	3.26	2.35	69	.07	.07	.02	.05	.19
Vegetable soybean	8.60	.67	.62	.07	1.10	.23	1.43	3.19
Chinese kale	1.32	1.08	.38	.04	.06	.07	.03	.14

[7]Relative Nutrient Cost = $\frac{\text{Production cost (baht/kg)}}{\text{Nutrient output (nutrient unit/kg)}}$

B = baht; Cal = kilocalories; IU = International Units.

As in Phase II, the percentage spent by gardening families on vegetables decreased and their consumption of vegetables increased. The daily intake of vegetables varied between 0.5 and 1.1 kg per household. Yield and daily nutrient contribution completely met the recommended dietary allowance (RDA) for a family of six in Vitamins A and C. This type of garden demonstrates that Vitamin-A

deficiencies, in areas like the northeast of Thailand, can be controlled through a proper increase of local food production.

Phase IV (ongoing). RNC and a modified and simplified version of F/FLS proved to be adequate for assessing the nutritional and socioeconomic impact of the gardens. Overall, the gardens have been accepted by the farm families and are being adopted by others in the area. Seeing their economic possibilities, some families expanded their gardens and grew crops for sale.

During this phase Kasetsart University, assisted by the Thai Department of Agricultural Extension, developed a tentative guide for starting a garden project in Thailand. This includes steps in the development of a garden, lessons in cooking, nutritional and economic assessment, nutrition education, and extension. The guide was tested in a workshop, modified, and is now being used by agricultural extension agents in five provinces of the northeast where malnutrition is a problem.

Conclusion

Backyard gardening was accepted by farm families, resulting in an increase in vegetable consumption and a decrease in food expenditure for the farm families of Bangpae. The combination of RNC and F/FLS methodologies are shown to be sufficient in providing planners and policy makers with the necessary data for assessing the impact of gardening. These methodologies are appropriate for use in developing countries, not only for impact assessment, but also for input-output, cost-benefit analyses. The gardening technologies are now being transferred to five other provinces in the northeast of Thailand.

The study was conducted to increase Kasetsart University's capabilities to do the kind of research and development necessary to expand the nutrition-related gardening concept to other areas of Thailand. Though the long-term goal of the project is to alleviate malnutrition, the short-term objective is to get the experience to do it. The study also demonstrated that scientists can work together as an interdisciplinary team.

The project has so far produced four reports and a training guide, all of which include details on the gardens, the pilot project site, the methodologies used, and garden results. Deficiencies, in areas like the northeast of Thailand, can be controlled through a proper increase of local food production.

New Vegetable Project

International Cooperation

AVRDC developed a program to collect and evaluate commercial cultivars of five species of vegetable crops and generate information useful to tropical countries. The five vegetables are cauliflower, sweet and hot pepper, mustard, Chinese radish, and snap bean.

Seed Distribution

Based on the results of the trials in 1982 to 1984, and partly depending on the willingness of original suppliers to provide the needed seeds, we finally selected 20 cultivars out of 646 initially collected accessions of the five crops (Table 1). These final selections were prepared as a recommended set and have been sent out to the national programs or our bilateral programs to be tested at different locations in countries such as Malaysia, Indonesia, Philippines, Thailand, and Saint Lucia.

Including the fixed sets mentioned above, we distributed a total of 888 seed packets of the five vegetables in 381 sets to 91 cooperators in 35 different countries (Table 2).

Table 1. Cultivars selected from the AVRDC new vegetable project for national adaptability trials.

Crop	Collection	Preliminary Selections[z]	Final Selections[y]	Remarks
Cauliflower	122	16	3	Chia Tai No.1, F1 451, Mikado 40 Days
Sweet pepper	126	9	3	Gypsy, Green Boy, Blue Star
Hot pepper	96	12	5	Farmers' Newcomer, Passion, Hungarian Yellow Wax, Twist Hot, Hong Shan Ho
Snap bean	154	19	3	Witsa, Black Creasback, Pai Chia 7
Mustard	41	7	3	Embrapa/Cenargen No.1, Crespa, Tender Green
Chinese radish	107	15	3	40 Days Early, Summer Top, Daeburyong
Total	646	78	20	

[z]Entries in the 1984 replicated trials. [y]Entries in the 1985 national trials.

Trials in Brunei

Mr. Raman F. Santiago, of the Sinaut Agriculture Training Center, Brunei has returned his trial data of the AVRDC new vegetable cultivars. Tables 3 to 7 show the results of the trials. F1 402 and F1 451 from Taiwan and Meigetsu from Japan performed best among the thirteen cauliflower entries included in the trial (Table 3). Chia Tai 1, which performed best in previous AVRDC trials, did not do well in Brunei, presumably because of the high incidence of bacterial soft rot.

Table 2. Distribution of new vegetable seeds during 1985.[z]

Crop	Sets		Packets		Cooperators	Countries
Sweet pepper	80	(18)	170	(48)	61	26
Hot pepper	95	(18)	274	(90)	78	28
Cauliflower	76	(18)	167	(40)	56	26
Radish	58	(18)	120	(48)	41	21
Mustard	18	(18)	54	(36)	16	10
Snap bean	42	(18)	103	(48)	26	15
Total	381	(18)	888	(310)	91	35

[z]Figures in parentheses refer to the fixed sets of final selections from AVRDC's previous trials, while the rest are customized sets upon specific requests.

Table 3. Best-performing AVRDC accessions of cauliflower in a trial at SATC, Brunei.[z]

Acc. No.	Cultivar	Days to Harvest	Harvest Rate (%)	Mean Curd Wt (g)	Marketable Yield (t/ha)
26	F1 451	52 e	100	109 c-f	8.9
27	F1 402	58 de	100	13 b-e	9.8
123	Meigetsu	57 de	100	154 b	13.4
	CV (%)	7.3	59	14	83

[z]At Sinaut Agriculture Training Center, transplanted on 4 Feb.1985 with two replications on a randomized complete block design. Mean separation in columns at the 5% probability level by Duncan's multiple range test.

In hot pepper, cv. Farmers' Newcomer, (a Taiwanese cultivar), one of the final AVRDC selections, outyielded other entries and showed more uniform maturity with less picking times (Table 4). Another AVRDC selection, cv. Passion, was more dispersed in maturity and its yield was less than cv. Farmers' Newcomer. Three other selections were not included in the trial. Cv. Pretty Red, a cooperator's own collection was comparable to Farmers' Newcomer.

Table 4. Performance of selected AVRDC hot pepper accessions in a trial at SATC, Brunei.[z]

Acc. No.	Cultivar	Days to flowering	Days to 1st harvest	No. of Pickings	Yield (t/ha)
1	Farmers' Newcomer	37	72	3	17.9
5	Passion	38	78	7	12.6
–	Golden Heat F1	36	67	7	6.8
–	Pretty Red	35	72	3	15.7

[z] At Sinaut Agriculture Training Center, seeded on 2 Jan.,1985 and transplanted on 16 Feb. with a single replication.

Cv. Chieftain, the highest-yielding sweet pepper cultivar among four entries, was harvested in a shorter period than others (Table 5). Blue Star, one of our selected cultivars, was far lower than Chieftain in yield, even though it was the second highest-yielding.

In radish, cv. 40 Days Early was the earliest in maturity and highest in yield among the six entries included in the trial. Two other cultivars, Kantsu and Daeburyong, also showed an economic yield level (Table 6). Both Daeburyong and 40 Days Early are included in our final selections.

Table 7 shows the performance of five snap bean entries in the wet and dry seasons in Brunei. There were apparent differences between the two trials in the number of pickings, pod size, and yield, although the cause of such differences is not known. Cultivar Witsa which was the best AVRDC selection, performed best with the biggest pod size and the highest yield. All three bush-type cultivars showed poor performances, as in the previous trials at AVRDC.

Table 5. Performance of selected AVRDC sweet pepper accessions in a trial at SATC, Brunei.[z]

Acc. No.	Cultivar	Days to flowering	Days to 1st harvest	Harvest Period (days)	No. of Pickings	Ave. Fruit Wt (g)	Yield (kg/ha)
50	California Wonder	56	92	12	2	16.6	817
1	Blue Star	42	67	37	3	63.2	5,851
?	Chieftain	49	78	16	2	50.0	17,160
47	Yolo Wonder	42	67	30	3	45.2	4,445

[z]At Sinaut Agriculture Training Center; sown on 2 Jan. and transplanted on 16 Feb. with a single replication.

Table 6. Performance of selected AVRDC radish accessions in a trial at SATC, Brunei.[z]

Acc. No.	Cultivar	Days to 1st Harvest	Yield (t/ha)	Remarks
1	40 Days Early	49	38.9	
19	Kantsu	54	31.5	
110	Daeburyong	60	18.9	
165	Ta-Pai	60	4.5	
167	Mei-Hwa	60	9.6	
check	Mimnowase Summe	–	0.0	SATC's old stock seeds

[z]At Sinaut Agriculture Training Center; sown on 2 Feb. 1985 with a single replication.

Table 7. Performance of selected AVRDC snap bean accessions in the wet and dry seasons at SATC, Brunei.

Acc. No.	Cultivar	Growth Habit	No. Pickings wet	No. Pickings dry	Wt/Pod (g) wet	Wt/Pod (g) dry	Yield (t/ha) wet	Yield (t/ha) dry
16	Yuang Ching	pole	7	10	10.5	5.1	9.5	10.30
53	Witsa	"	7	10	18.5	6.4	30.9	10.10
26	Yaemidori	bush	4	9	13.8	4.1	0.8	2.23
70	Cimbola	"	3	6	10.8	4.4	1.7	1.42
155	Early Bush	"	5	7	11.2	4.9	6.2	3.67

[z]At Sinaut Agriculture Training Center; trials were sown on 15 Jan. (wet) and 2 May 1985 (dry) without replications.

Evaluation Trial for Sweet Pepper

Introduction

Although the three best sweet pepper cultivars out of 126 initial entries were selected from previous simple trials at AVRDC in 1982-84, further evaluations with more replications and locations were yet to be made in order to obtain more reliable information on varietal performance. One summer trial at AVRDC was included in a regional adaptability-test program supported by the Council of Agriculture, Taiwan, China with a set of previously selected cultivars.

Materials and Methods

Ten entries including two different seed sources of the cultivar Gypsy, were sown on 20 May and transplanted on 9 July. F1 hybrid seeds of cvs. Blue Star and Citadel were obtained from the original suppliers, while the seeds of other entries were previously multiplied at AVRDC. The plot was a 4.8-m-long double-row bed. The distance between centers of two adjacent beds was 1.5 m and

between hills, 0.4 m. A randomized complete block design was employed with four replications.

Fertilizer rate was 210, 180, and 210 kg/ha of N, P, and K, respectively, applied basally and in five top dressings during the growing period. Immediately after transplanting, plots were mulched with rice straw and properly irrigated throughout the growing period. Fruits at optimum maturity were harvested mostly at seven- to ten-day intervals, starting on 26 August with the earliest-maturing entry, Gypsy, to 4 November.

Results and Discussion

Table 8 shows uniformity, maturity, leaf color, and disease severity of each entry. Only cvs. Citadel and Gypsy (original seed) showed a satisfactory level of homogeneity, when judged by overall observations on plant height, growth habit, color and fruit shape. Cv. Blue Star was not uniform in these aspects, even though the original F1 seeds were used.

Table 8. Uniformity, maturity, and disease severity of sweet pepper cultivars in a trial at AVRDC 1985.

Cultivar	Uniformity[z]	Leaf Color	Maturity[y] (DAT)	Disease Score[x]		Sources
				virus	others	
Blue Star	Poor-Fair	DG	64 a-d	4	2	Known You, Taiwan, China
Chiu Feng	Fair	DG	67 ab	4	2	Hsing Nong, Taiwan, China
Citadel	Good	DG	66 abc	2	2	Peto Seed, USA
Gypsy A	Good	DG	48 e	3	3	Peto's original seed
Gypsy B	Poor-Fair	DG	59 cd	3	3	Peto (Multiplied at AVRDC)
Dalbon	Poor	DG	70 a	4	3	Peto Seed, USA
Avelor	Fair	DG	70 a	2	2	Embrapa/Cenargen, Brazil
Cubanelle	Fair	G	57 d	4	4	Keystone, USA
Yolo Wonder B	Fair	DG	67 ab	3	3	"
Resistant Florida Giant	Fair	DG	60 bcd	2	2	Ferry-Morse, USA
LSD .05			7			

[z]Overall observations on the plots. [y]Mean separation in columns at the 5% probability level by Duncan's multiple range test. [x]Rating by overall observation from 1 for no symptom to 5 for severe infestation.

In addition to virus diseases, southern blight, *Sclerotium rolfsii*, and Phytophthora blight were recognized in the field by our plant pathologists. Cvs. Citadel and Resistant Florida Giant showed the least disease development and cv. Cubanelle, the highest. Gypsy was the earliest-maturing followed by Cubanelle. Difference in maturity was significant between the two seed sources of Gypsy.

Fruit color of this cultivar was greenish yellow or pale green, while it was light or dark green in other entries (Table 9). Blue Star and Chiu Feng produced the heaviest fruits, while Gypsy and Avelor showed the lowest unit fruit weight. Measurement of length and/or width of the fruit did not match with weight. It must be because of differences among cultivars in fruit thickness, and placenta and seed development inside the fruits. Avelor and Cubanelle produced thinner-walled fruits than other entries. Of interest was that there was no significant differences in all fruit characters between the two seed sources of Gypsy.

F1 Gypsy and Blue Star were the highest in yield because of high fruit number per plant in the former and high fruit weight in the latter (Table 10). Cubanelle produced many fruits per plant, but its yield was low because of small fruit size. Gypsy multiplied at AVRDC was significantly lower than F1 Gypsy in yield. This difference was largely attributed to the higher number of fruits per plant in the original F1 seeds, which were obtained by the longer harvest period. Harvest started much earlier in the F1 seed, while it ended at around the same time as in the other source of seed.

Table 9. Fruit characters of sweet pepper cultivars in a trial at AVRDC 1985.[z]

Entry	Fruit Color[y]	Mean Fruit Wt (g)	Mean Fruit Length (cm)	Mean Fruit Diam. (cm)	Fruit Shape Index (L/D)	Mean Fruit Thickness (cm)
Blue Star	DG	70 a	11.3 ab	6.9 ab	1.65	0.50 a
Chiu Feng	DG	70 a	8.7 e	7.3 a	1.20	0.45 ab
Citadel	DG	51 c	6.1 c	6.5	0.93	0.45 ab
Gypsy A	GY	39 d	9.9 cd	5.5 cd	1.80	0.45 ab
Gypsy B	GY	40 d	10.5 bc	5.6 cd	1.88	0.50 a
Dalbon	DG	67 a	9.3 ed	7.0 ab	1.30	0.43 ab
Avelor	DG	37 d	6.3 f	5.9 c	1.10	0.33 c
Cubanelle	LG	29 e	11.6 a	5.1 d	2.30	0.38 bc
Yolo Wonder B	DG	60 b	6.6 f	6.9 ab	0.98	0.48 a
Resistant Florida Giant	DG	57 b	6.3 f	7.0 ab	0.90	0.50 a
LSD .05		5	0.9	0.5		0.07

[z]Mean separation within columns at the 5% probability level by Duncan's multiple range test.
[y]DG = dark green; GY = greenish yellow; LG = light green.

Table 10. Yield and component characters of sweet pepper cultivars in a trial at AVRDC 1985.[z]

Entry	No. Fruit Harv./Plant	Fruit Wt/ Plant (kg)	Marketable Fruit Yield (t/ha)
Blue Star	22.7 ed	1.59 ab	52.9 ab
Chiu Feng	19.0 ef	1.33 bc	44.3 bc
Citadel	26.5 d	1.36 bc	45.4 bc
Gypsy A	46.5 a	1.79 a	59.7 a
Gypsy B	36.3 bc	1.43 bc	47.8 bc
Dalbon	16.7 ef	1.12 cd	37.5 cd
Avelor	34.2 c	1.27 bcd	42.3 bcd
Cubanelle	42.9 ab	1.25 bcd	41.6 bcd
Yolo Wonder B	15.1 f	0.90 d	30.0 d
Resistant Florida Giant	21.5 def	1.23 bcd	40.9 bcd
LSD .05	6.8	0.34	11.3

[z]Mean separation within columns at the 5% probability level by Duncan's multiple range test.

Conclusion

In a summer trial for sweet pepper cultivars, ten sweet pepper entries were included. Two F1's, Gypsy and Blue Star, were the highest in yield, mainly because of high number of fruits per plant in the former and to large fruit size in the latter. Avelor and Cubanelle produced thin-walled fruits. The original F1 seed of Gypsy showed a longer harvest period and, consequently, a higher number of fruits per plant and yield than the seed advanced therefrom at AVRDC. The difference between the two seed sources was not significant in unit fruit size.

Nutrition Chemistry

Availability of Provitamin A in Sweet Potato

Introduction

Vegetables and fruits are rich sources of vitamins and minerals for cereal-based diets in most developing countries. In Taiwan, 54% and 33% of dietary Vitamin A come from vegetables and fruits, respectively. However, plants are a relatively poor source of Vitamin A because of the low biological availability of carotene which is only about 16.6% of animal Vitamin A. There are also variations in the availability of provitamin A with different plants.

The orange-red sweet potato developed at AVRDC is recommended as an excellent source of Vitamin A in the tropics. Chemical analysis has shown that the Beta-carotene content of some sweet potato lines can be higher than that of carrots. However, the availability of sweet potato provitamin A has not been studied systematically. In this study, the bioassay method was used to estimate the availability of provitamin A in sweet potato and other selected vegetables.

Materials and Methods

1st experiment. Sweet potatoes with orange-red (TN 64) and white (CN 941-32) flesh were obtained from regional yield trials of the Development Program. Beta-carotene was isolated and purified from the orange-red sweet potato. All the chemicals and ingredients used, including retinyl acetate, were analytical in grade and free of carotenoids.

Male Long-Evans rats, 21 days old, were purchased from the animal center of National Taiwan University. The rats were fed a diet without Vitamin A (consisting of corn starch - 66.2%, casein-22%, soybean oil - 6%, salt mixture - 4%, and a vitamin mixture without Vitamin A) for four weeks for depletion purposes. Four rats in each treatment were fed the test diet for 10 days after the depletion period. Test diets were made from Vitamin A- free diet mixed with retinyl acetate, carotenoids extract from sweet potato, raw sweet potato, and sweet potato extract with fresh, white sweet potato. Livers and kidneys were removed from the rats 48 hours after the assay period and were frozen until the analysis of retinol content.

2nd experiment. Sweet potato samples were the same as in the first experiment. A Vitamin-A-free diet was fed to the experimental rats right after weaning. Few rats were sacrificed during the depletion period to make sure that the stored Vitamin A dropped to undetectable level before bioassay. Test diets were made from Vitamin-A-free diet mixed with all-trans Beta-carotene; raw sweet potato; cooked, fried, and baked sweet potato; raw and cooked sweet potato leaves; and raw and cooked carrot.

Analysis of Vitamin A. The organs were ground in a Waring blender and tissue homogenizer with ethanol and then saponified with 10% KOH ethanol solution for 15 min in a water bath of 70°C. The saponified solution was extracted with ethyl ether, and the alkaline ethanol solution was washed with water in a separatory funnel. The ethyl ether layer was collected and dried by a stream of nitrogen

gas, the residue was dissolved with an HPLC mobile solvent (49:49:2), and injected into the HPLC for the determination of retinol content.

Results and Discussion

A purified Beta-carotene diet and a Vitamin-A-free diet were included in the two experiments as control. The recovery of Vitamin A was calculated based on the following formula:

$$\text{Vitamin A recovery (\%)} = \frac{\text{retinol stored in treatment} - \text{retinol stored in Vit.-A-free control}}{\text{total intake of provitamin A}}$$

Two levels of provitamin A intake were tested in the first experiment for all the four treatments: retinyl acetate, Beta-carotene, orange-fleshed sweet potato, and Beta-carotene + white-fleshed sweet potato. The retinol recovered in the liver and kidney are summarized in Table 1. Rats of the retinyl acetate treatment had the best recovery rate. More than 50% retinol was recovered in the liver and kidney of the test animals. Beta-carotene recovery was about one-half that of retinyl acetate. This result agrees with information found in literature.

Table 1. Availability of Beta-carotene in sweet potato fed to rats.

Treatment	Retinol or Beta-Carotene Intake (μg)	Recovered as Retinol in liver (μg)	in liver (%)	in kidney (μg)	in kidney (%)	availability (%)
Control I	0	39.77 ± 9.23	0	15.37 ± 2.15	-	0
Control II	0	36.49 ± 13.62	0	11.03 ± 0.51	-	0
Retinyl acetate	835 ± 36.2	459.00 ± 46.8	50.7 ± 3.6	5.52 ± 2.37	-	50.7 ± 3.6 b
Retinyl acetate	1571 ± 6.0	954.00 ± 49.9	57.8 ± 4.0	4.75 ± 1.27	-	57.8 ± 4.0 a
Sweet potato extract	995 ± 2.7	245.00 ± 35.9	21.2 ± 3.6	11.92 ± 1.80	-	21.2 ± 3.6 c
Sweet potato extract	1883 ± 24.6	412.00 ± 32.8	20.0 ± 1.6	3.73 ± 0.75	-	20.0 ± 1.6 cd
Sweet potato	956 ± 72.3	180.00 ± 35.9	15.1 ± 3.0	8.56 ± 4.14	-	15.1 ± 3.0 de
Sweet potato	1917 ± 25.3	282.00 ± 14.6	13.0 ± 0.8	6.48 ± 1.91	-	13.0 ± 0.8 e
Sweet potato extract with sweet potato	951 ± 48.7	223.00 ± 22.4	19.8 ± 1.8	6.82 ± 1.59	-	19.8 ± 1.8 cd
Sweet potato extract with sweet potato	1875 ± 27.5	386.00 ± 67.9	18.8 ± 3.6	7.22 ± 2.33	-	18.8 ± 3.6 cd

There was no significant difference in Beta-carotene recovery from animals fed the Beta-carotene basal diet and those given the white sweet potato diet. The recovery was lower in those on the orange-red sweet potato diet, which is about 70% of the Beta-carotene treatment. This value is higher than the recovery reported for other plant materials.

It has been reported that cooking improves the availability of provitamin A in plants. So, sweet potato was cooked in different ways and provitamin A availability was estimated and compared with other vegetables in the 2nd experiment. The results are summarized on Table 2. The relative recovery of purified Beta-carotene in raw sweet potato was 64.3% which is slightly lower than that of the previous experiment, probably because of the low retinol level in the liver at the initial stage of the assay period. The relative recovery in raw sweet potato tips and carrots was only 16.5% and 35.5%, respectively.

These results suggest that sweet potato root is a more efficient Vitamin A source than carrot or sweet potato tips. Cooking did improve the availability of these vegetables. However, boiling and baking significantly reduced the availability of Vitamin A in sweet potato root. The reason is not known. This negative effect is not found on fried sweet potato.

Vitamin A recovery can be affected by many factors, such as Vitamin A intake, protein intake, retinol in the liver after depletion, and even the living environment. Two experiments were conducted with different liver retinol levels before the assay period: 40 μg in the first experiment and nondetectable in the second. Growth practically stopped at the end of the depletion period in both experiments.

Table 2. Availability of carotene in sweet potato, sweet potato leaves, and carrots under different processing conditions.

Treatment	Beta-Carotene	Recovered as Retinol			
	Intake Amt (μg)[y]	in liver (μg)	in kidney (μg)	total (μg)	availability (%)
Beta-carotene	940 ± 78.4	105.8 ± 21.8	5.5 ± 2.5	111.3 ± 21.4	11.8 ± 1.6 a
Raw sweet potato	1342 ± 81.9	96.6 ± 12.9	5.4 ± 1.3	102.0 ± 13.5	7.6 ± 0.7 b
Cooked sweet potato	983 ± 14.3	39.0 ± 9.6	8.1 ± 3.3	47.1 ± 6.7	4.8 ± 0.7 c
Fried sweet potato	1078 ± 2.6	78.1 ± 2.0	8.1 ± 3.7	86.2 ± 5.24	8.0 ± 0.5 b
Baked sweet potato	1082 ± 97.1	41.0 ± 5.7	7.1 ± 3.7	48.1 ± 4.2	4.5 ± 0.8 c
Raw sweet potato leaves	1422 ± 17.2	21.3 ± 8.1	6.2 ± 3.6	27.5 ± 8.7	1.9 ± 0.6 d
Cooked sweet potato leaves	1411 ± 38.2	33.7 ± 9.7	5.2 ± 1.5	38.9 ± 8.2	2.7 ± 0.6 d
Raw carrot[z]	1176 ± 72.7	43.1 ± 10.8	6.4 ± 2.5	49.5 ± 9.4	4.2 ± 0.6 c
Cooked carrot[z]	1176 ± 46.1	49.3 ± 6.5	6.8 ± 2.1	56.1 ± 6.6	4.8 ± 0.7 c
Control	0	–	–	–	–

[z]In the case of carrot, provitamin A activity of alpha-carotene is calculated as 50% of Beta-carotene. [y]Expressed as Beta-carotene equivalent

Retinol recovery in the second experiment was much lower than that in the first experiment (20% vs. 11% for Beta-carotene). Although the relative recovery of Beta-carotene in raw sweet potato was comparable, the experimental condition of the 1st experiment is recommended. Higher retinol content in the organ made chemical analysis much easier. In experiment 1, the small amount of retinol in the kidney may even be ignored without significantly affecting the overall result.

The biological process of carotene absorption in the intestines is very complex and not yet understood in detail. The variations in availability of provitamin A found among different types of vegetables listed in the Food Composition Table, is not very clear. More work will be needed to better understand the true nutritional value of vegetables.

Conclusion

Although vegetables and fruits are rich in provitamin A, the biological availability of Vitamin A is poor. These experiments on rats showed that the availability of provitamin A in sweet potato is higher than in other vegetables. Boiling and baking reduced this availability, however. Frying is recommended.

The Effect of Sweetpotato Weevil Damage on the Palatability of Sweet Potato

Introduction

Sweet potato can be used both for human food and animal feed. Sweetpotato weevil, however, spoils its appearance and flavor, thus reducing its market value. The compound reported to be responsible for the unpleasant odor is ipomeamarone, a terpene. This compound can be produced in sweet potato tissues through the induction process of terpene-inducing factors present in the larvae of the weevil. In this study, terpene analysis and rat-feeding experiments were conducted to estimate the effect of weevil damage on the palatability of sweet potato for the experimental animals.

Materials and Methods

Sweet potato roots in different stages of weevil larvae infestation were analyzed for terpene concentration. The method of Hyodo et al. was used.* Sweet potato roots were dried and ground into powder, then exposed to the air. Two grams of sweet potato powder were taken every 24 h, and terpene concentration was determined.

* H. Hyodo, I. Uritani, and S. Akai 1969. Production of furano-terpenoids and other compounds in sweet potato root tissue in response to infection by various isolates of *Ceratocystis fimbriata*. Phytopathol. Z., 65.332.

Male rats (Long-Evans), 21 days old, were purchased from the animal center of National Taiwan University. They were fed the control diet for one week before the bioassay was initiated. Two groups of ten rats each were housed in individual cages. Four feed boxes, each filled with a different test diet, were placed in the corner of the cages. The position of feed boxes were changed everyday. The concentration of terpenes in each test diet of the two groups are shown in Table 3. The rats were fed with the test diet for a period of ten days and feed intake was recorded everyday.

Table 3. Terpene concentration of test diet in group 1 and group 2 of the preference test.

Treatment	Terpene Concentration (O.D. 527 nm)	
	group 1	group 2
Control	0.060	0.06
1	0.074	0.11
2	0.088	0.15
3	0.110	0.18

In the intake test, the composition of the test diet in each treatment and terpene concentrations are shown in Table 4. Each test diet was a mixture of a basal diet mixed with different combinations of larvae-infested and uninfested sweet potato. Four rats in each treatment were fed with 20 g of the test diet per day for a period of 10 days, and feed intake was recorded everyday.

Table 4. Composition of test diet and terpene concentration.

Treatment	Basal Diet (g)	WL-SP[z](g)	SP[y](g)	Total (g)	Terpene[x]
Control	0	0	10	20	0.060
1	10	2	8	20	0.088
2	10	4	6	20	0.132
3	10	6	4	20	0.160
4	10	8	2	20	0.206
5	10	10	0	20	0.260

[z]WL-SP = Weevil-larvae-infested sweet potato. [y]SP = sweet potato (clean). [x]Terpene concentration was monitored at 527 nm.

Results and Discussion

Fig. 1 shows that, in the preference test, the experimental rats detected the terpene taste even at very low terpene concentration, 0.074 (about 3.6 weevil/kg sweet potato). Rats almost refused to eat any test diet when the concentration of terpene reached 0.18 (about 8.7 weevil/kg sweet potato). Fig. 2 presents the daily intake in each diet of Group 1. There was no difference in intake of weevil-damaged diets per rat at the beginning and at the end of the experimental period. This result suggests that preference did not change after 10 days of feeding, if the rats were given a free choice.

The conditions in the intake experiment were different from those of the preference test. Weevil-damaged feed was the only feed available in the former. The animals were forced to select between the less preferred diet or starvation. Total intake at the end of the experimental period for each diet are presented in Fig. 3. Food intake decreased with increasing concentrations of terpene. The feed intake per rat of the diet with high terpene concentration was only 75% of that of the control diet. Body weight gain was also affected by low feed intake. This implies that a weevil-damaged diet will either prolong feeding period or reduce feed efficiency. In either case, it will increase livestock production cost.

The number of larvae per unit root weight is the recommended parameter to quantify the degree of weevil damage. This method, however, is not applicable to dehydrated sweet potato chips and flour which are commonly used in the feed industry. An acceptable method must be found to grade these

commodities based on degree of weevil damage. Chemical analysis on weevil-damage-related constituents, such as terpene, could be a possible solution.

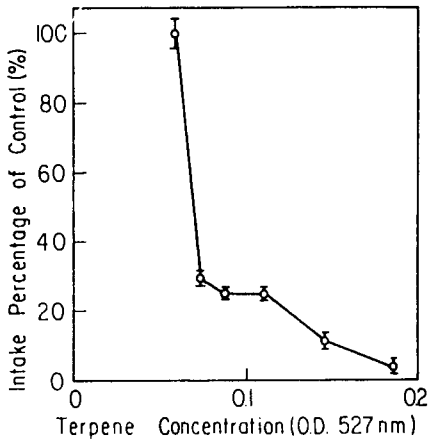

Fig. 1.

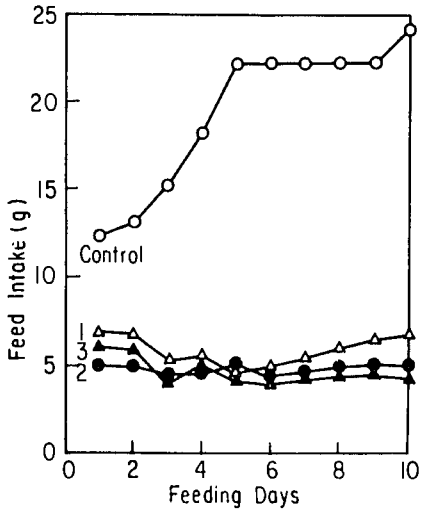

Fig. 2.

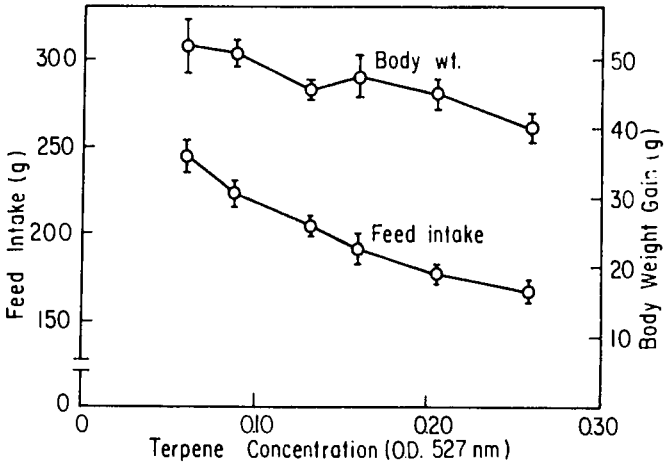

Fig. 3.

Fig. 1. Relationship between terpene concentration and feed intake (preference test).

Fig. 2. Daily intake of each test diet in group 1 of the preference test.

Fig. 3. Relationship among terpene concentration, feed intake, and weight gain of rats (intake test).

The relationship between weevil infection, expressed as number of larvae per unit weight and terpene concentration, is shown in Fig. 4. The relationship between these two parameters is not linear, however. Terpene concentration did not increase proportionately with the increase in larvae in the sweet potato sample. Terpene concentration, therefore, is not a good parameter for estimating samples with heavy weevil infection. However, feeding experiments revealed that animals are very sensitive to weevil damage. Terpene concentration can still provide useful information for feed purposes.

Terpene is a volatile compound, and a certain loss is expected during storage. Results presented in Fig. 5 indicated that loss of terpene occurred only at the beginning stage of the storage period and concentration reached a stable stage after four days under room temperature.

Conclusion

Weevil damage reduces the market quality of sweet potato. Terpene content was used as an index to evaluate an acceptable damage level of sweet potato for animal feed. Experimental animals were

found to be very sensitive to terpene content. Although it was suggested that terpene is the principal compound affecting the palatability of weevil-damaged sweet potato, the experiment design did not exclude the possibility of other contributing factors. Additional experiments will be needed if one wishes to clarify this point.

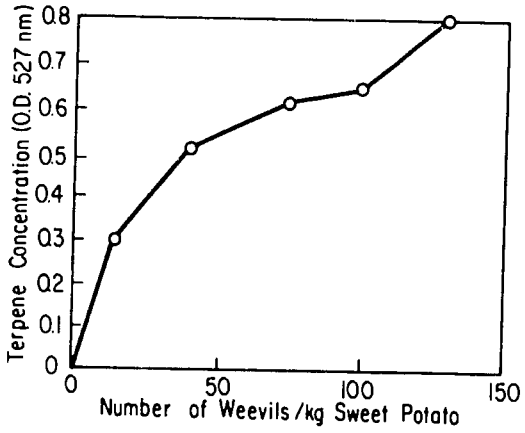

Fig.4. Relationship between number of weevils and terpene concentration.

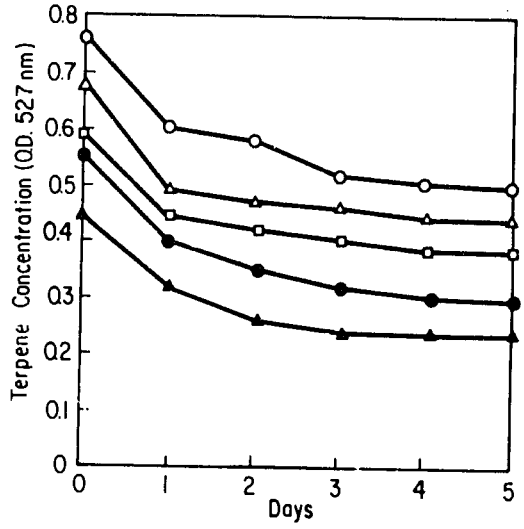

Fig. 5. Volatilization of terpene in the weevil-larvae-infested sweet potato powder.

Composition of Edible Fiber in Sweet Potato Tips

Introduction

Sweet potato tips are used as a vegetable in many Asian countries. This nutritious vegetable, however, is not considered a high quality vegetable because of its tenderness. Edible fiber content and its composition are believed to be associated with the texture of vegetables. Recent research indicated that dietary fiber may have a restraining effect on many diseases.

The development of cultivars as vegetable greens is one of the objectives of the AVRDC sweet potato improvement program. CN 1508-93 was selected on the basis of its field performance. The edible fiber composition of this cultivar and three other sweet potato lines were analyzed in this project. Water convolvulus was also included for comparison.

Materials and Methods

Sweet potato tips (top 10 cm) of variety I-57, I-426, CN 1367-2, and CN 1508-93 were picked from the AVRDC field. Water convolvulus tips (25 cm) were obtained from home garden plots.

Fresh samples were separated into leaf, petiole, and stem; and then weighed immediately. Their distributions in all the samples were calculated. Proximate chemical compositions were analyzed as follows: moisture-oven dry method (105°C); crude protein-micro-Kjeldahl method (N x 6.25); crude fiber-acid and alkaline hydrolysis method; starch-perchloric acid hydrolysis method; ash-550°C furnace method.

Enzymatic hydrolysis for carbohydrate composition was adapted from Prosky et al. (1983).* Protease, termamyl, and amyloglucosidase were used to hydrolyze ground dried samples into hot water

*Prosky, L., N-G Asp, I. Furda, J. W. De Vries, T. F. Schweizer, B. Harland. 1984. The determination of total dietary fiber in foods, food products and total diets: interlaboratory study. J. AOAC 67:1044-1052.

(60°C) soluble and insoluble nonstarch polysaccharides (NSP). NSP were hydrolyzed by 67% H_2SO_4 and 1.0 N H_2SO_4 to determine cellulose and hemicellulose contents, respectively. The pectic substance was determined by hydrolyzing NSP with tetraborate/H_2SO_4 reagent. Free sugar, titratable acidity, iron, and Beta-carotene contents were analyzed according to the methods of the Association of Official Analytical Chemists.

CN 1508-93 tips and water convolvulus were chosen for sensory evaluation. It was done in the practice kitchen of the Tainan Junior College of Home Economics. The panel consisted of 41 girls around 20 years old. The two vegetables were cooked in two ways: stir-frying and boiling. The panel members evaluated the vegetables for color, texture, palatability, after taste, and total acceptability.

Results and Discussion

The fresh weight distributions of the four lines of sweet potato tips and water convolvulus are listed in Table 5. The stem of water convolvulus contributes 53.9% of the total fresh weight. This high stem weight may be due to the different sampling methods used. The whole plant, including the main stem, is considered edible. Line CN 1508-93 has long petioles which contribute 37.9% of the edible portion. This morphological characteristic makes this line more suitable as a vegetable green, especially in areas where only petioles are eaten.

Table 5. Proximate chemical composition of four varieties of sweet potato tips and water convolvulus.

Variety	Portion	Weight Distribution (%)	DM[z] (% of FW)[y]	Protein (% of DM)	Crude Fiber (% of DM)	Starch (% of DM)	Free Sugar (% of DM)	Ash (% of DM)	Fe (mg/100 g)	Beta-Carotene (mg/100 g)
I 57	Total		12.17	19.38	15.66	3.83	9.97	13.55	3.35	2.66
	Stem	24.0	9.54	11.91	24.03	3.97	13.98	14.39	3.74	0.36
	Petiole	29.5	7.28	11.65	17.33	4.37	10.70	19.64	1.37	0.47
	Leaf	46.5	16.64	28.15	10.29	3.41	7.43	9.25	4.41	5.24
I-426	Total		12.95	24.56	14.16	3.53	9.20	13.66	3.03	1.21
	Stem	23.6	9.82	17.08	18.51	3.83	13.53	13.76	1.75	0.32
	Petiole	20.8	7.92	14.77	16.54	4.17	14.95	17.78	1.79	0.17
	Leaf	55.6	16.16	31.39	11.43	3.16	5.21	12.07	4.04	1.97
CN 1367-2	Total		12.44	18.77	14.95	3.76	7.30	13.34	3.01	0.61
	Stem	30.4	9.54	11.93	19.54	3.93	10.41	13.23	1.41	0.27
	Petiole	21.3	8.52	11.80	16.05	4.87	7.44	17.64	1.81	0.18
	Leaf	48.3	15.99	26.14	11.58	3.17	5.29	11.51	4.55	1.01
CN 1508-93	Total		6.62	20.67	15.00	3.63	12.99	16.67	1.53	2.54
	Stem	24.4	7.92	14.06	20.79	3.37	16.84	14.92	1.52	1.63
	Petiole	37.9	5.92	13.25	17.06	4.00	15.68	22.27	0.80	0.14
	Leaf	37.7	6.47	32.42	9.19	3.43	7.79	12.18	2.27	5.53
Water convolvulus	Total		6.50	28.38	14.75	3.20	6.23	19.85	5.39	1.94
	Stem	53.9	5.00	22.10	17.82	3.65	7.36	22.61	4.11	0.31
	Petiole	11.9	5.46	22.54	16.25	4.21	5.21	22.49	3.89	0.71
	Leaf	34.2	9.23	40.30	9.35	2.13	4.81	14.57	7.94	4.95

[z]DM = dry matter [y]FW = fresh weight.

Table 5 also summarizes selected chemical compositions. Three of sweet potato lines had a total dry matter content of over 12%. Dry matter content of CN 1508-93 was only about half of the other lines and was comparable to water convolvulus. Since crude fiber content of these four sweet potato lines were comparable, the low dry matter content of CN 1508-93 reduced its crude fiber content of the fresh weight sample to less than 1%, which is comparable to water convolvulus and other tropical leafy vegetables (e.g., leafy amaranths), although it is still higher than those of temperate vegetables, such as Chinese cabbage and spinach. The panel test suggests that this line is better in tenderness than other lines tested.

Water convolvulus had a higher iron content than the sweet potato lines. CN 1508-93 was relatively poor in iron. I-426 and CN 1367-2, which have yellowish-green leaves were low in Beta-carotene content. Potato lines, I-426 and CN 1367-2, were lower in Beta-carotene content.

Nonstarch polysaccharides (NSP) are the major component of both sweet potato tips and water convolvulus. This component contributes about 60% of total dry matter. Proportion of hot-water-

soluble NSP to insoluble NSP is around 1:5. The major compositions of soluble NSP and insoluble NSP are listed in Tables 6 and 7. Compositions listed are around 80% of total edible fiber. Other components, such as gum and lignin, were not included in the analysis. Hemicellulose was the major NSP for both sweet potato tips and water convolvulus. The concentration of cellulose estimated by this fractionation method agreed with the crude fiber content as shown in Table 5.

Table 6. Carbohydrate composition of soluble nonstarch polysaccharides of four varieties of sweet potato tips and water convolvulus (dry weight basis).

Variety	Portion	Starch (%)	Pectic Substance (%)	Cellulose (%)	Hemicellulose (%)
I-57	Total	1.26	14.25	0.13	43.82
	Stem	1.21	8.11	–	38.26
	Petiole	1.09	9.63	–	38.55
	Leaf	1.40	20.34	0.02	50.03
I-426	Total	1.32	17.97	0.10	46.77
	Stem	1.69	11.60	0.27	42.96
	Petiole	1.37	11.41	–	41.20
	Leaf	1.15	23.13	0.06	50.47
CN 1367-2	Total	1.22	18.63	0.21	47.37
	Stem	1.30	10.39	0.58	42.67
	Petiole	1.12	14.70	0.02	43.99
	Leaf	1.21	25.54	0.07	51.79
CN 1508-93	Total	1.43	21.86	0.59	47.09
	Stem	1.21	16.79	0.32	44.44
	Petiole	1.30	19.33	0.74	41.49
	Leaf	1.69	27.69	0.62	54.44
Water convolvulus	Total	1.87	14.58	0.90	41.71
	Stem	0.97	4.88	0.14	37.37
	Petiole	1.09	9.70	0.01	40.02
	Leaf	3.56	31.56	2.40	49.14

Since the hot-water-soluble NSP is extracted during cooking, the insoluble NSP is probably the major constituent affecting the texture. It is pointed out that there is a relatively high insoluble pectic substance in the petiole of CN 1508-93. This component may be a contributing factor in the tender texture of this cultivar.

Water convolvulus has lower titratable acidity and free sugar than sweet potato tips. However, the laboratory panel was not able to detect the difference in taste among sweet potato tips with regard to higher sugar to acid ratio.

Edible-fiber analysis showed that CN 1508-93 had good eating quality as vegetable green, but in the sensory evaluation of whole tips at the Tainan Junior College of Home Economics, the panel still preferred water convolvulus in all aspects (Table 8). CN 1508-93 with its long and good-quality petiole, has probably a better chance in areas where only petioles are consumed.

Conclusion

Tenderness in sweet potato tips hinders its full acceptance as a green leafy vegetable by consumers. Regarding edible fiber content, the new AVRDC breeding line CN 1508-93 showed long petioles with high pectic content which may suggest a better eating quality than the check cultivars. Organoleptic evaluation, however, indicated that it is less acceptable than water convolvulus.

Table 7. Carbohydrate composition of insoluble nonstarch polysaccharides of four varieties of sweet potato tips and water convolvulus (dry weight basis).

Variety	Portion	Starch (%)	Pectic Substance (%)	Cellulose (%)	Hemicellulose (%)
I-57	Total	1.76	10.30	26.65	45.74
	Stem	1.89	11.84	32.70	46.37
	Petiole	2.13	14.91	32.43	46.71
	Leaf	1.46	6.59	19.86	44.81
I-426	Total	1.80	9.03	28.94	46.16
	Stem	2.22	11.69	35.38	47.70
	Petiole	2.28	14.41	37.82	47.52
	Leaf	1.45	5.89	22.89	44.99
CN 1367-2	Total	1.65	8.63	33.46	45.91
	Stem	2.15	11.97	38.55	47.07
	Petiole	1.75	11.42	34.92	46.89
	Leaf	1.30	5.29	29.62	44.75
CN 1508-93	Total	2.03	12.55	33.15	44.80
	Stem	2.13	9.88	44.79	45.71
	Petiole	2.56	21.83	39.23	46.50
	Leaf	1.43	4.95	19.50	42.50
Water convolvulus	Total	2.03	9.72	30.72	44.15
	Stem	2.48	14.31	36.97	47.01
	Petiole	1.83	13.74	26.13	46.73
	Leaf	1.39	1.08	19.00	38.75

Table 8. Sensory evaluation scores of CN 1508-93 tips and water convolvulus prepared in two cooking methods.[z]

Cooking Method	Sample	Color	Texture	Palatability	After Taste	Total Acceptability
Stir-frying	CN 1508-93	5.14 b	5.00 b	4.48 b	4.50 b	4.55 b
	Water convolvulus	6.16 a	6.41 a	6.18 a	6.18 a	6.31 a
Boiling	CN 1508-93	5.59 ab	5.20 b	4.91 b	4.48 b	4.93 b
	Water convolvulus	5.93 a	5.86 a	5.98 a	5.77 a	5.93 a

[z]No. of members in panel = 41.

Cooking Quality of Mungbean

Introduction

In Taiwan, mungbean produced domestically is mainly used for soup preparation. Ease in cooking with a resulting good flavor are considered desirable components in this preparation. Studies at AVRDC indicated that the 30-min cooking time is not stable for a given variety. This suggests that other environmental factors might be involved which affect the cooking quality of mungbean seed. This study was conducted to identify these factors. Efforts were also made to relate some chemical and physical properties to this hard-to-cook legume seed.

Materials and Methods

Nine varieties of mungbean sown in different seasons were chosen for this experiment. Two hundred mungbean seeds were cooked in 150 ml water for 20 to 25 min in Erlenmeyer flasks placed on a

hot plate. The number of well-cooked seeds were recorded. Cooking time was expressed as the time when 50% of the beans were split.

Five varieties of mungbean sown in summer 1985 were picked for storage test. Samples were put in a desiccator with glycol (75% RH) and stored under 40 ± 1 °C in the oven for 45 days. Cooking quality was determined after storage.

Varieties V 2010 and VC 1168-B were compared on cooking quality and sensory evaluation. The percentages of well-cooked beans at four different cooking times were determined. Sensory evaluation was done in the small room of the AVRDC Chemistry Department in a normal environment. The panel was composed of the chemistry staff who were trained to undergo organoleptic tests. The triangle test was used for sample evaluation.

Results and Discussion

Crop seasons and storage periods were selected as possible factors that might affect the cooking time of mungbean seeds. The number of well-cooked seeds in 22 min of cooking time was the preliminary criterion applied for mungbean samples sown in different seasons. The results are summarized in Table 9. The following trends were observed from this experiment: 1) varietal differences were detectable in seeds planted in the same season. (Lines such as V 2984, V 2272, and V 2773 were easier to cook than V 3726 and V 2010); 2) seeds from the autumn season had better cooking quality than those of the summer and spring seasons; 3) storage duration affected cooking time.

A preliminary experiment was conducted to test the effect of storage on cooking time. Mungbean seed samples sown in the same crop season were stored at 40°C and 75% RH for 45 days. The percentages of well-cooked beans observed before and after storage are listed in Table 10. Results suggest that storage might prolong cooking time. Storage effect was more severe on some varieties, such as V 3726, than others. The experiment on long-term storage is still ongoing.

V 2010 is a popular cultivar in Taiwan. Laboratory experiments indicated that it needs a longer cooking time. VC 1168B, an AVRDC line, recommended for release in the near future, required less cooking time than V 2010. The percentages of well-cooked beans at four different cooking times are presented in Table 11.

Table 9. Cooking quality of different varieties of mungbean planted under different seasons.

Variety	Crop Season	Well-Cooked Beans in 22 min (%)	Well-Cooked Beans in 25 min (%)
V 3476	83 autumn	55 a ±7.4	97 a ± 1.9
V 3476	84 autumn	60 a ±5.1	99 a ± 1.0
V 3476	85 spring	30 c ±5.5	66 b ± 10.7
V 3476	85 summer	11 d ±2.5	54 b ± 2.9
V 2010	84 autumn	11 d ±3.2	29 c ± 9.1
V 2010	85 spring	7 d ±2.8	23 c ± 4.6
V 2010	85 summer	3 e ±1.2	7 d ± 1.5
VC 1628-A	84 autumn	33 c ±2.1	93 a ± 2.5
VC 1628-A	85 spring	30 c ±3.0	85 a ± 3.1
VC 1628-A	85 summer	29 c ±2.9	
VC 1168-B	85 spring	58 a ±8.4	
VC 2530-C	85 spring	35 c ±2.3	
V 2272	85 summer	54 ab ±0.9	
V 2984	85 summer	57 a ±3.3	
V 2773	85 summer	51 b ±3.4	
V 3726	85 summer	10 d ±4.8	

The triangle test was applied for sensory evaluation of V 2010 and VC 1168-B. The results are summarized in Table 12. The panel considered texture as the major property. VC 1168-B was softer than V 2010. Interestingly, the panel preferred VC 1168-B if both varieties had the same cooking

time. On the other hand, when V 2010 was cooked longer to approximate the texture of VC 1168-B, the panel favored V 2010 because it had acquired a better flavor.

Table 10. Comparison of cooking quality between fresh and stored mungbeans.[z]

Variety No.	Percentage of Well-Cooked		% Reduction
	fresh beans mean SD	stored beans mean SD	
V 2272-85 summer	78 ± 0.0	68 ± 2.5	10
V 2773-85 summer	75 ± 5.5	70 ± 2.5	5
V 3726-85 summer	50 ± 9.5	7 ± 1.0	43
V 2010-85 summer	12 ± 4.5	3 ± 1.0	9
V 2984-85 summer	85 ± 5.5	70 ± 0.0	15

[z]41 ± 1°C, 75% RH, 45 days; cooking time = 25 min.

Table 11. Effect of cooking time on the percentage of well-cooked mungbean varieties, V 2010 and V 1168-B.[z]

Cooking Time (min)	V 2010 mean SD	VC 1168-B mean SD
18		5 ± 1.0
20		30 ± 2.5
22	7 ± 2.8	58 ± 8.4
25	23 ± 4.6	95 ± 3.6
27	73 ± 4.5	
30	96 ± 2.5	

[z]Seeds were planted in spring 1985.

Table 12. Sensory evaluation of mungbean soup prepared from V 2010 and VC 1168-B.

Cooking Time[z]	Panel Number	Significance[y]	Preference[y]
10 min for both	12	ns	** for VC 1168-B
12 min for both	10	**	** for VC 1168-B
12 min for VC 1168B 16 min for V 2010	16	**	* for V 2010

[z]Autoclaved under 120°C.
[y]ns = not significant; * = significant; ** = highly significant.

Chemical and physical properties, such as water absorption rate, coat thickness, amylose content, fiber composition, and lignin content, have been suggested as factors that might be related to cooking time requirement. Results of the preliminary experiments, however, did not provide enough evidence to establish a significant relationship between any of these factors and cooking time. Further experiments will be needed to understand the chemistry involved in cooking and to establish a method for quality evaluation.

Conclusion

A long cooking time is undesirable for dry beans. The required cooking time for mungbean seed is affected by crop season and storage period. AVRDC breeding line VC 1168-B was a better line than the local check cultivar V 2010 as regards cooking time.

Quality Constituents of Soybean AGS Lines

Introduction

AVRDC has developed 290 soybean lines, many of which were released by national programs for commercial production. Information on food constituents with commercial interest is lacking for most of these AGS lines. The purpose of this project was to accumulate such information for reference. Chemical constituents planned for analysis include crude protein, crude fat, total methionine content, fatty acid pattern, lipoxygenase activity, storage properties, and protein patterns. Constituent analyses conducted in 1985 were on crude protein, crude fat, lipoxygenase activity, and part of the fatty acid pattern.

Materials and Methods

Since soybeans were not planted for the purposes of this experiment, harvest season and year were not the same for all the lines analyzed. Therefore, the data can be used only for reference.

Crude fat and crude protein were analyzed with the Near Infrared Spectroscopy (Technicon Model 400) calibrated by the standard soxhlet and micro-Kjeldahl methods, respectively. Fatty acid patterns were determined by gas chromatography after saponifying and esterifying the extracted fat. The gas chromatography (GC) condition used was 15% DEGS 1/4 in. x 5 ft column and Flame Ion Detector (FID) detecter. Lipoxygenase activity was determined spectrophotometrically with linoleic acid as substrate. One unit of enzyme activity was defined as an absorbance increase of 0.01 $(min)^{-1}$ at 234 nm.

Isoenzyme patterns of lipoxygenase were examined by disc electrophoresis. Soybeans were soaked for four hours and distilled. The trapped volatiles were extracted with CS_2 four times and concentrated and analyzed by GC with 5% XF1150, 1/8 in. x 10 ft. column. N_2 was used as a carrier gas with the flow rate of 8 ml/min. Oven temperature was initiated at 60°C for 2 min and then raised to 180°C at a rate of 2°C per min. The temperature of FID was 250°C.

Results and Discussion

The frequency distribution of crude fat and crude protein are shown in Figs. 6 and 7, respectively. For oil-extraction plants in Taiwan, the minimum requirements are 36% protein and 18% fat. Among 290 AGS lines tested, 17 lines met this requirement. Eight lines (AGS 110, 100, 137, 274, 76, 70, 72, and 177) had high protein (>42%) and fat (<20%).

High protein content is a desirable property for traditional oriental food, such as tofu and bean-curd skin. The top 10 AGS lines on protein content were 118, 2, 199, 104, 193, 20, 281, 106, 260, and 162. All these 10 lines have more than 44% protein content. Among these lines, AGS 118, 104, 20, and 260 which have an oil content higher than 18% deserve further evaluation.

Soybean oil is one of the most important oil source for food. It consists of 60% polyunsaturated fatty acid, 25% oleic acid and 15% saturated fatty acid. Polyunsaturated fatty acids are essential fatty acids, but they reduce the stability of oil. One characteristic of soybean oil is its high concentration of linolenic acid (18:3) which is even less stable than linoleic acid (18:2). A desirable fatty acid pattern for soybean oil should be high in total polyunsaturated fatty acid but low in linolenic acid. The analysis of the fatty acid pattern of AGS lines is not yet completed. The variation of total unsaturated fatty acids varied from 58 to 64% of fat. The lowest linolenic acid lines was around 6% fat.

Lipoxygenase is reportedly responsible for the unpleasant odor of soybean products. The distribution of enzyme activity (lipoxygenase-1) among AGS lines are shown in Fig. 8. AGS lines 293, 295, 185, 273, and 212 had relatively low lipoxygenase activity.

Isoenzymes of lipoxygenase can be detected by electrophoresis. The method used in this experiment can only detect the activity of L_1 lipoxygenase which is reportedly the major isoenzyme in soybean. Selected lines, high or low in L_1 isoenzyme, were subjected to electrophoresis to estimate the activity

of L_2 and L_3 isoenzymes. It was found that lines relatively low in L_1 were also generally low in L_2 and had no L_3.

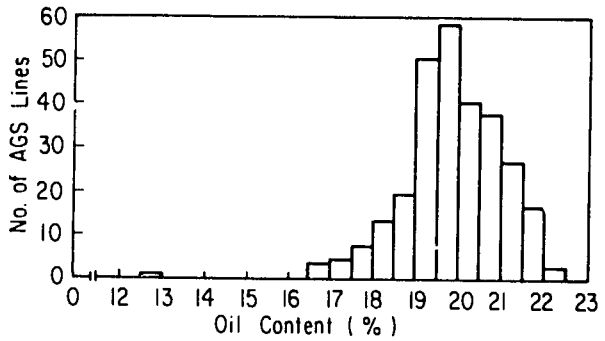

Fig. 6. Distribution of oil content in AGS lines.

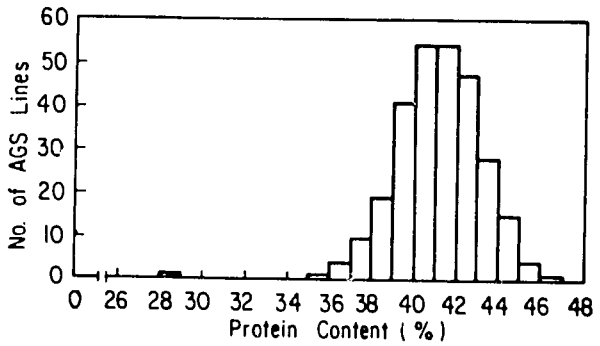

Fig.7. Distribution of protein content in AGS lines.

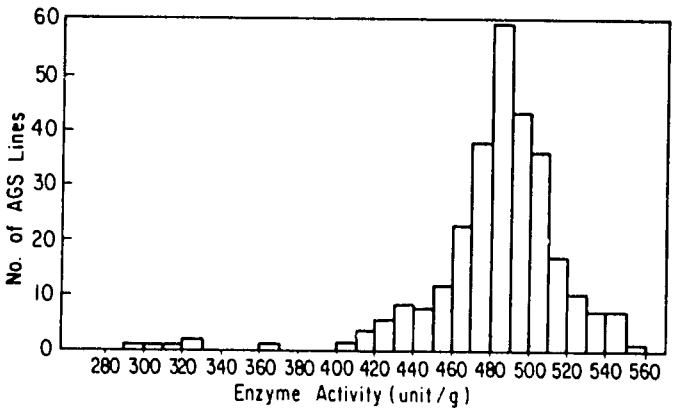

Fig. 8. Distribution of enzyme activity in AGS lines.

Although the differences in lipoxygenase activities among AGS lines were not great, lines of high and low enzyme activities were selected to test the effect of the enzymes on flavor (Table 13). Lines with high lipoxygenase activity were also high in major flavor compounds. This result suggests that lipoxygenase activity could be a useful index of soybean acceptability.

Table 13. Major volatiles of soybean lines high and low in lipoxygenase-1 activity.

AGS	Lipoxygenase-1 Activity[z]	Standard[y] μg/100 g				No. of Unidentified Major Peaks
		1	2	4	7	
AGS 46	126.6	1.07	1.40	0.32	0.29	4
AGS 87	128.0	0.24	1.91	0.14	0.39	4
AGS 9	162.3	11.25	3.81	5.67	0.62	4
AGS 33	162.6	16.39	3.25	7.18	0.57	4

[z]One unit of enzyme activity was defined as an absorbance increase of 0.01 $min^{-1}(mg)^{-1}$at 234 nm.
[y]Standard 1 is ethyl vinyl ketone, 2 is n-hexanal, 4 is n-heptyl aldehyde, 7 is 2-octanone.

Conclusion

The purpose of this study was to provide certain information on the quality of selected AVRDC AGS lines. Lines high in both protein and fat are available, and so are those very high in protein but with slightly lower fat content. These lines are good for tofu-making. Lipoxygenase activity of AGS lines varied from 85 to 170 units per milligram. Flavor pattern determined by gas chromatography on lines high and low in enzyme activity suggests that activity of lipoxygenase can be a potential indicator of the beany flavor in soybean milk. Lines identified with special properties will be planted in the field with replications for reconfirmation and quantitative comparison.

Volatiles of Processed Soybean Products

Introduction

The beany flavor often becomes a deterrent to the acceptability of soybean processed products. Carbonyl compounds are suggested to be the ones responsible for the distinctively undesirable beany and grassy flavor. These compounds believed to be the degradation of unsaturated fatty acids and the oxidation process is catalyzed by lipoxygenase. Ethyl vinyl ketones, n-hexanal, 3-cis-hexanol and n-pentylfuran have been identified as the most important ones responsible for this objectionable flavor.

The gas chromatographic analysis was conducted to study the flavor of soybean products prepared in the traditional way. The purpose of this study was to identify soybean products with low beany flavor for better acceptability in other places.

Materials and Methods

AVRDC soybean seeds were selected and cleaned before processing:

- For raw soybean milk, whole soybean seeds were soaked for 4 h in distilled water below 40°C, ground in a waring blender for 5 min, and diluted to 2,000 ml for distillation.
- For bean sprouts, soybean seeds were soaked in water for 6 h and placed in an automatic laboratory sprouting can.
- For tofu and bean-curd skin, the seeds were soaked in water, ground in a waring blender, and subjected to a laboratory process.
- For vegetable soybean, fresh seeds were cooked for 15 min, ground, and processed the same way as raw soybean milk.

The distillation system is shown in Fig. 9. The volatiles distilled and trapped in containers were extracted with CS_2 four times and concentrated for gas chromatography (GC) analysis.

In gas chromatography, the volatiles were analyzed by GC on 5% XF1150, 1/8 in. x 10 ft. column. N_2 was used as a carrier gas with the flow rate of 8 ml/min. Oven temperature was initiated at 60°C for 2 min and then raised to 180°C at the rate of 2°C per min. The temperature of the flame ion detector (FID) was 250°C.

Results and Discussion

The gas chromatogram of volatile compounds from raw soybean milk (AGS 66) is shown in Fig. 10. A baseline shift at the later part of the chromatogram was observed. At maximum instrument sensitivity and relatively high sample concentration, eight peaks could be observed. The retention time of available standards, ethyl-vinyl-ketone, hexanal, n-heptyl-aldehyde, ethyl-n-hexanoate, n-hexanol, 2-octanone, 1-octen-3-01 could be tentatively identified. Identification of compounds, such as n-heptyl-aldehyde and ethyl-n-hexanoate , based on retention time, are less reliable because of longer retention time.

Major volatiles from sprouts of four soybean varieties and quantitative estimation based on peak heights are listed in Table 14. Ethyl vinyl-ketone, hexanol, n-heptyl-aldehyde and 2-octanone were the major volatile compounds in soybean sprouts. No drastic differences were observed on volatile compound patterns among varieties tested, including the small-seeded variety, AGS 2. The concentration of volatile compounds in sprouts significantly decreased after cooking. Ethyl vinyl ketone and n-heptyl-aldehyde were found to be the major volatile compounds in cooked soybean sprouts, just as in mungbean.

The GC pattern of volatile compounds extracted from tofu are listed in Table 15. The major volatile compounds identified were similar to that of soybean milk. Extending the boiling period of soybean milk before adding the coagulate reduced the concentration of volatiles. The boiling effect is more pronounced on compounds with low molecular weight, such as ethyl vinyl ketone and n-heptyl aldehyde, than on compounds with high molecular weight, as 2-octanone. Prolonged cooking time did not affect the tofu-making property of soybean milk.

Table 14. Major volatiles of bean sprouts.

Sample	Concentration μg/100 Dry Wt. Standard[z]					Number of Unidentified Major Peaks
	1	2	4	6	7	
AGS 66						
Fresh sprout	13.61	28.22	5.68	–	12.54	4
Cooked sprout	6.94	0.77	2.47	–	–	3
AGS 129						
Fresh sprout	15.29	17.92	2.04	0.91	7.23	6
Cooked sprout	13.87	0.29	8.25	–	–	4
AGS 2						
Fresh sprout	25.10	46.22	11.99	–	24.79	6
Cooked sprout	11.41	0.67	5.79	–	–	4
TN 15						
Fresh sprout	13.71	38.90	7.80	–	21.79	6
Cooked sprout	5.08	0.35	1.94	–	–	1
TN 3						
Fresh sprout	39.79	–	40.90	–	–	3
Cooked sprout	7.04	1.00	3.81	0.98	5.33	3

[z]Standard 1 is ethyl vinyl-ketone, 2 is n-hexanal, 4 is n-heptyl aldehyde, 6 is n-hexanol, 7 is 2-octanone.

Bean-curd skin is one soybean product with a better chance at consumer acceptance because of its low beany flavor and good storability. The GC analysis supported this result (Table 16). Only few small peaks were observed in gas chromatogram. The major flavor compound of bean-curd skin was ethyl-vinyl-ketone which had a concentration of 10 to 20% that of tofu on a dry weight basis. It is expected to be even lower after rehydration.

Conclusion

The undesirable beany and grassy flavor of tofu and bean-curd skin is often a deterrent to consumer acceptability. Flavor patterns of these traditional soybean products were analyzed by gas chromatography and showed that their major volatiles were similar to these in soybean milk. Bean-curd skin had very low carbonyl compounds, which suggests that it has a better chance of being accepted by the consumers.

Table 15. Major volatiles of tofu.

Sample	Concentration μg/100 g Dry Wt. Standard[z]				Numbers of Unidentified Major Peaks
	1	2	4	7	
AGS 66					
Tofu	68.13	5.45	35.00	0.60	8
B 10 tofu[y]	26.83	2.45	19.25	0.67	6
AGS 129					
Tofu	44.65	3.10	23.62	0.28	6
B 10 tofu[y]	5.28	2.71	2.66	0.57	7

[z]Standard 1 is ethyl vinyl ketone, 2 is n-hexanal, 4 is n- heptyl-aldehyde, 7 is 2-octanone.
[y]B 10 tofu was boiled for 10 min before being processed into tofu.

Table 16. Major volatiles of bean-curd skin.

Sample	Concentration μg/100 Dry Wt. Standard[z]				Numbers of Unidentified Major Peaks
	1	2	4	7	
AGS 66	8.91	0.80	4.56	0.21	2
AGS 129	2.34	0.41	0.41	0.09	2
AGS 2	6.06	0.76	1.86	0.31	1
TN 15	25.07	–	16.95	–	1

[z]Standard 1 is ethyl vinyl-ketone, 2 is n-hexanal, 4 is n-heptyl-aldehyde, 7 is 2-octanone.

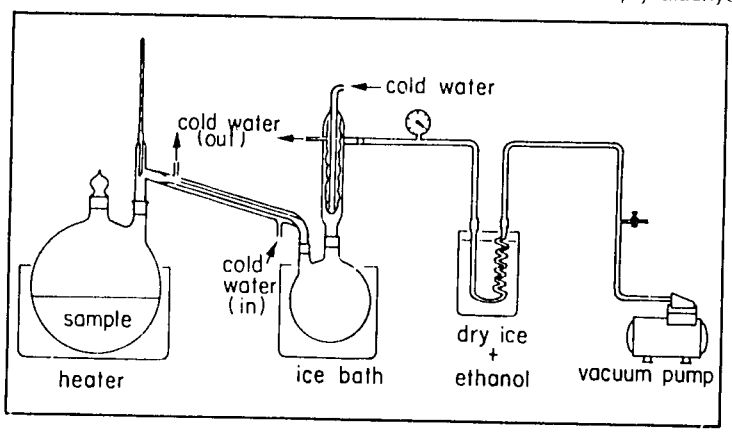

Fig. 9.
Vacuum distillation system for collecting volatiles from soybean products.

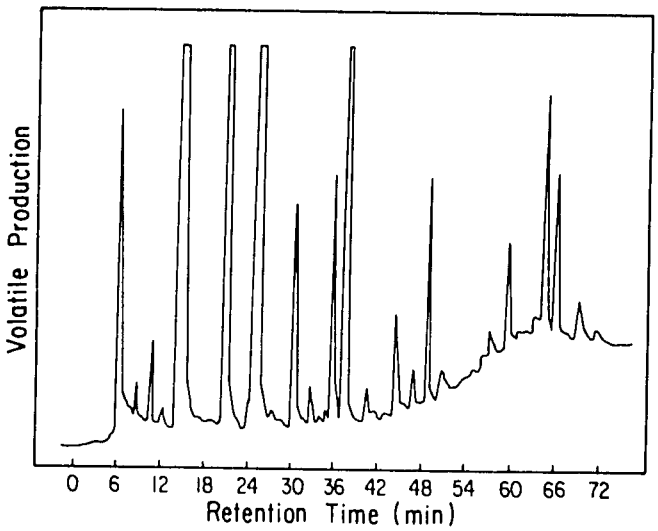

Fig. 10.
Gas chromatogram of the volatile components from soaked soybean milk of AGS 66.

Soil Science

Developing Improved Cropping Systems

Introduction

Crop rotation is beneficial to the soil: it preserves organic matter, increases nitrogen, balances soil nutrients, improves its physical properties, and suppresses soil-borne diseases. This project, which was begun in 1983 and will continue in successive years, will attempt to 1) develop crop rotation systems specifically tailored to the tropics; 2) evaluate the effects of previous crops and successive applications of mulch and compost on tomato and soybean yields; 3) develop new technologies feasible for vegetable cultivation in summer in the humid tropics; and 4) develop labor-, fertilizer-, chemical-, and water-saving crop rotation systems.

Materials and Methods

Ten cropping sequences were tested in 1985 (Table 1). Individual crops were planted in 50 m^2 plots. A completely randomized design was used with two replications. Although fertilizer application rate for each crop was different in each cropping sequence and among different cropping sequences, the total amounts of N, P, and K applied per annum in each cropping system were fixed at the rate of 150, 120, and 180 kg/ha, respectively (Table 2).

Table 1. Rotation system tested for AVRDC mandate crops.

Rotation No.	Spring	Summer	Autumn
1	rice	mungbean	tomato
2	mungbean	rice	sweet potato
3	soybean	C. cabbage	buckwheat
4	tomato	corn	soybean
5	soybean	sweet potato	C. cabbage
6	C. cabbage	tomato	mungbean
7	C. cabbage (30 t/ha compost + mulching)	tomato (30 t/ha compost + mulching)	mungbean
8	C. cabbage (mulching)	tomato (mulching)	mungbean
9	rice	tomato (30 t/ha compost + mulching)	soybean (30 t/ha compost + mulching)
10	rice	tomato (mulching)	soybean

Table 2. Application of fertilizer in each rotation system.

Rotation No.	Planting Time	Crop	Fertilizer Used[z]	Dressing	Fertilizers Applied (kg/ha)			
					N	P_2O_5	K_2O	Compost (t/ha)
1	autumn	tomato	CF#4	basal	70.0	35.0	140.0	0.0
			CF#1	top	30.0	7.3	15.0	0.0
	spring	rice	CF#39	basal	25.0	37.8	25.0	0.0
	summer	mungbean	CF#4	basal	25.0	12.5	50.0	0.0
2	autumn	s. potato	CF#4	basal	40.0	20.0	80.0	0.0
			CF#39	top	20.0	30.0	20.0	0.0
	spring	mungbean	CF#39 + KCl	basal	30.0	45.0	50.0	0.0
	summer	rice	CF#1	basal	60.0	15.0	30.0	0.0
3	spring	soybean	CF#4	basal	50.0	70.0	100.0	0.0
	summer	C. cabbage	CF#5	basal	100.0	50.0	75.0	0.0
4	autumn	soybean	CF#39	basal	40.0	60.0	40.0	0.0
	spring	tomato	CF#5	basal	70.0	35.0	52.0	0.0
			CF#4	top	40.0	20.0	80.0	0.0
5	autumn	C. cabbage	CF#5	basal	70.0	35.0	52.8	0.0
	spring	soybean	CF#39	basal	40.0	60.0	40.0	0.0
	summer	s. potato	CF#4	basal	40.0	20.0	80.0	0.0
6	autumn	mungbean	CF#39 + KCl	basal	15.0	22.5	25.0	0.0
	spring	C. cabbage	CF#39	basal	50.0	75.0	50.0	0.0
	summer	tomato	CF#1 + KCl	basal	85.0	21.0	112.5	0.0
7	autumn	mungbean	CF#43 + super phosphate	basal	20.0	32.0	20.0	0.0
	spring	C. cabbage	CF#39	basal	50.0	75.0	50.0	30.0
	summer	tomato	CF#1 + KCl	basal	80.0	20.0	100.0	30.0
8	autumn	mungbean	CF#43 + super phosphate	basal	20.0	32.0	20.0	0.0
	spring	C. cabbage	CF#39	basal	50.0	75.0	50.0	0.0
	summer	tomato	CF#1 + KCl	basal	80.0	20.0	100.0	0.0
9	autumn	soybean	CF#2	basal	40.0	32.0	65.0	30.0
	spring	rice	CF#43	basal	25.0	25.0	25.0	0.0
	summer	tomato	CF#43	basal	50.0	50.0	50.0	30.0
			CF#39	top	35.0	53.0	35.0	0.0
10	autumn	soybean	CF#2	basal	40.0	32.0	65.0	0.0
	spring	rice	CF#43	basal	25.0	25.0	25.0	0.0
	summer	tomato	CF#43	basal	50.0	50.0	50.0	0.0

[z]Compound fertilizers (CF) N-P_2O_5-K_2O; #1 = 20-5-10; #2 = 10-8-16.5; #4 = 11-5.5-22; #5 = 16-8-12; #39 = 12-16-12; #43 = 15-15-15-4 (MgO).

Results and Discussion

Yield. The yield of mungbean cultivated in the spring or autumn was always very low (Table 3). It became nearly nil in the second cultivation on the same plot because of serious root damage brought about by *Fusarium*. Mungbean, however, yielded fairly high in the summer planting and did not show any symptom of the root disease even in the second cultivation.

Table 3. Mungbean yield in different cropping sequences.

Previous Crop	Planting Time	Yield (t/ha)
1. Rice	1983, autumn	0.78 ab
2. Sweet potato	1984, spring	1.07 b
3. Rice	1984, summer	2.10 a
4. Tomato	1984, autumn	0.00 d
5. Sweet potato	1985, spring	0.37 c
6. Rice	1985, summer	1.90 a
LSD (0.05)		0.52

Soybean, on the other hand, showed no growth retardation in autumn and spring. Spring soybean yielded nearly 4 t/ha even in the second cultivation (Table 4). Thus, soybean is far more tolerant to continuous cropping than mungbean; hence, it can be cultivated on the same place without any serious growth retardation for a couple of successive years. Mungbean, which is very susceptible to successive cultivation, should not be planted continuously on the same soil. Its introduction into cropping systems is not recommended, except for summer planting especially in the subtropics.

Table 4. Soybean yield in different cropping sequences.

Rotation No.	Previous Crops	Planting Time	Yield (t/ha)
1	corn	1983, autumn	2.59 cd
2	buckwheat	1984, spring	3.74 a
3	Chinese cabbage	1984, spring	3.87 a
4	corn	1984, autumn	2.63 c
5	tomato + compo.	1984, autumn	3.09 b
6	tomato	1984, autumn	2.31 d
7	buckwheat	1985, spring	3.85 a
8	Chinese cabbage	1985, spring	3.73 a
LSD (0.05)			0.30

Sweet potato yield decreased significantly in the second cultivation both in autumn and summer plantings (Table 5). Symptoms associated with continuous cropping, however, were not clearly seen in sweet potato growth. Chinese cabbage yields decreased greatly year by year, except for rotation nos. 3 and 6 in which 100 kg/ha of nitrogen or 50 kg N plus 30 t/ha sugarcane cake (about 150 kg/ha N is contained in terms of total nitrogen), respectively, were applied (Table 6). This indicates that nitrogen was a limiting factor in the high yield of Chinese cabbage; therefore, in these cropping sequences, at least, 100 kg/ha of nitrogen should be applied to each cultivation of Chinese cabbage.

Table 5. Sweet potato yield in different cropping sequences.

Previous Crop	Planting Time	Marketable (t/ha)	Total (t/ha)
1. Rice	1983, autumn	17.59 a	22.28 a
2. Soybean	1984, summer	12.05 b	13.31 bc
3. Rice	1984, autumn	14.72 ab	16.99 b
4. Soybean	1985, summer	8.23 c	9.67 c
LSD (0.05)		3.23	3.78

Rice yield also decreased sharply with frequency of cultivation, and the hunger signs for nitrogen appeared in rotation no. 2 in the summer cultivation of 1985 (Table 7). Thus, nitrogen application

rate of 150 kg/ha per annum to each cropping sequence is too small to get economical high yields, and should be increased to 200 kg/ha (Table 11). In the summer planting of 1985, tomato yielded nearly three times as much as that in 1984 in rotation nos. 7 to 10. This was mainly due to the introduction of new heat-tolerant CL 5915-153.

Compost application did not produce any difference in tomato yield, but rice straw mulch increased yield significantly. It is primarily important, therefore, to avoid hazardous high temperature and heavy rain damage in summer tomato cultivation when introducing a highly heat-tolerant cultivar and such cultural practices as mulching and high pot cultivation.

Table 6. Chinese cabbage yields in different cropping sequences.

Previous Crop	Planting Time	Yield (t/ha)	
		head	total
1. Sweet potato	1983, autumn	27.97 ab	54.77 ab
2. Mungbean	1984, spring	25.65 ab	47.98 bc
3. Soybean	1984, summer	27.05 ab	52.40 ab
4. Sweet potato	1984, autumn	21.58 b	47.05 bc
5. Mungbean	1985, spring	12.22 c	31.38 d
6. Mungbean	1985, spring	30.31 a	65.42 a
7. Mungbean	1985, spring	14.70 c	35.90 cd
8. Soybean	1985, summer	30.74 a	58.34 ab
LSD (0.05)		6.51	13.12

Table 7. Rice yield in different cropping sequences.

Rotation No.	Previous Crop	Planting Time	Yield (t/ha)
1	tomato	1984, spring	4.84 a
2	mungbean	1984, summer	4.68 a
1	tomato	1985, spring	4.23 ab
9	soybean	1985, spring	3.73 bc
10	soybean	1985, spring	3.40 bc
2	mungbean	1985, summer	3.10 c
LSD (0.05)			0.85 0

Nutrient concentration in soils. All the results are summarized in Table 8. Soil pH varied only by one unit through five successive cultivations of different crops, and it lay within the desired range for crop growth (between 6.50 and 7.50). Soil EC varied in the different cropping sequences, mainly corresponding to the amount of fertilizer applied; however, planting time affected soil EC more than the cropping sequences did. Autumn planting (dry season) resulted in higher soil EC than in the other plantings, because a large quantity of Ca and Mg was introduced into each experimental plot through irrigation water in the dry season. EC was always higher after spring rice than after summer rice when more than 70% of annual precipitation was accumulated in the season.

Introduction of legumes in crop rotation positively increased T-N (See cropping sequences containing SB or MB, e.g., BW-SB-CC,SB-T-CO). T-N decreased greatly after CC cultivation in all the cropping sequences, and this fact agreed well with the successive decrease in its yield owing to insufficient nitrogen as pointed out previously. Compost application increased T-N greatly and minimized yield loss due to nitrogen deficiency.

Soil phosphorus (P) gradually increased with more frequent crop cultivation. Cropping sequences, T-MB-CC, increased soil P steeply. Soil P, however, did not change significantly in cropping system T-SB-R. After several crop cultivations with P application and incorporation of plant residue, P concentration gradually increased and accumulated.

Soil (K) greatly decreased after summer planting because of a lot of rainfall. The application of K fertilizer reflected soil K proportionally, that is, it increased steeply after tomato and sweet potato (SP) cultivation (heavy fertilizer application) and decreased sharply after buckwheat (BW) and corn (CO)(no fertilizer). Of interest is that soil K increased greatly with legume (especially SB) cultivation. Compost application also increased soil K in the summer planting. CC and summer MB increased available calcium (Ca) and so did compost application to summer crops.

Table 8. Nutrients accumulated in the soil in different crop sequences, since autumn of 1983.[z]

Rotation No.	Crop, Season and Year[y]	pH	EC	T-N[x] (%)	Inorg. N (ppm)	Ava. P (ppm)	Ava. K (ppm)	Ava. Ca (ppm)	Ava. Mg (ppm)	T-C (%)	C/N
1	TOAU3	7.08	0.61	–	23.8	22.8	58.9	–	–	0.85	–
	RCSP4	7.35	0.26	0.089	–	30.0	30.4	2891	291	0.91	10.2
	MBSU4	7.40	0.13	0.085	–	22.1	31.5	1984	174	0.75	8.8
	TOAU4	7.02	0.31	0.085	27.3	36.0	65.3	1758	162	0.76	9.0
	RCSP5	7.06	0.26	0.083	7.5	33.8	46.1	1609	229	0.79	9.5
	MBSU5	7.39	0.18	0.085	27.6	38.3	47.7	1985	151	0.65	7.6
2	SPAU3	7.00	0.38	–	40.5	26.6	48.3	–	–	0.74	–
	MBSP4	7.18	0.12	0.081	–	29.6	73.1	1619	157	0.77	9.5
	RCSU4	6.64	0.16	0.081	–	22.0	37.2	1491	175	0.73	9.0
	SPAU4	6.53	0.29	0.085	27.4	26.7	75.0	2126	205	0.77	9.0
	MBSP5	6.95	0.17	0.085	21.2	47.9	77.0	1486	188	0.77	9.1
	RCSU5	6.58	0.18	0.080	16.8	37.9	22.4	1417	170	0.63	7.8
3	BWAU3	6.73	0.58	–	22.0	26.1	47.4	–	–	0.76	–
	SBSP4	7.36	0.13	0.084	–	23.5	90.3	1600	160	0.83	9.9
	CCSU4	7.34	0.19	0.154	–	23.3	28.5	1954	206	0.75	4.9
	BWAU4	7.16	0.17	0.079	27.8	34.2	39.2	1557	175	0.76	9.6
	SBSP5	6.77	0.16	0.088	20.5	127.4	86.2	1494	177	0.76	8.7
	CCSU5	7.67	0.33	0.080	23.4	46.7	24.9	1944	213	0.71	8.8
	BWAU5	7.25	0.18	0.109	20.5	24.5	29.2	1988	228	–	–
4	SBAU3	6.86	0.44	–	14.5	24.4	32.7	–	–	0.72	–
	TOSP4	7.37	0.12	0.083	–	30.9	93.3	1587	184	0.81	9.7
	COSU4	7.27	0.19	0.155	–	32.3	37.4	1966	180	0.76	4.9
	SBAU4	5.80	0.49	0.090	54.0	67.7	122.1	1952	172	0.70	7.8
	TOSP5	7.27	0.14	0.082	15.5	52.8	55.8	1414	181	0.77	9.4
	COSU5	7.33	0.15	0.075	19.9	37.9	23.0	1475	155	0.57	–
	SBAU5	7.45	0.22	0.081	14.5	28.2	41.5	1800	195	–	–
5	CCAU3	6.80	0.47	–	18.3	23.9	70.5	–	–	0.76	–
	SBSP4	7.24	0.13	0.082	–	26.4	65.2	1617	159	0.83	10.1
	SPSU4	7.17	0.13	0.083	–	23.7	37.4	1599	170	0.77	9.2
	CCAU4	7.22	0.34	0.083	31.4	25.1	92.4	1502	166	0.76	9.2
	SBSP5	7.13	0.12	0.086	10.5	44.8	89.0	1376	161	0.77	9.0
	SPSU5	7.33	0.16	0.086	15.9	38.2	30.7	1694	181	0.69	–
	CCAU5	7.42	0.42	0.087	41.5	27.8	63.1	1933	219	–	–
6	MBAU3	6.93	0.38	–	27.3	25.1	38.1	–	–	0.76	–
	CCSP4	7.33	0.15	0.077	–	28.1	34.3	1806	187	0.77	10.0
	TOSU4	7.29	0.16	0.078	–	24.7	34.6	1743	170	0.71	9.0
	MBAU4	6.87	0.26	0.083	35.4	35.7	84.2	1745	178	0.70	8.4
	CCSP5	7.59	0.28	0.077	19.3	56.8	54.8	1641	205	0.72	9.4
	TOSU5	7.19	0.29	0.078	18.4	38.4	51.6	1567	165	0.55	7.0
	SBAU5	7.59	0.19	0.076	15.3	30.6	44.7	1875	200	–	–
7	TOSU4CM	6.06	0.17	0.080	–	36.4	89.0	1266	123	0.79	9.8
	MBAU4	6.18	0.23	0.085	17.6	51.4	105.4	1468	154	0.80	9.5
	CCSP5CM	7.14	0.56	0.088	11.2	61.9	76.0	1664	232	0.83	9.5
	TOSU5CM	7.05	0.40	0.105	31.6	87.2	156.1	1700	176	0.85	8.0
	SBAU5	7.22	0.28	0.106	19.5	60.7	96.8	1918	215	–	–
8	TOSU4M	6.56	0.15	0.077	–	36.2	67.6	1287	138	0.75	9.8
	MBAU4	6.41	0.21	0.087	23.2	54.0	110.0	1678	162	0.71	8.1
	CCSP5M	7.14	0.17	0.081	10.9	60.8	88.1	1230	167	0.78	9.7
	TOSU5M	6.69	0.36	0.085	30.6	66.7	97.9	1364	160	0.61	7.1
	SBAU5	7.26	0.22	0.900	17.1	47.7	75.5	1593	195	–	–
9	TOSU4CM	6.47	0.21	0.081	–	45.9	48.3	1398	152	0.81	10.0
	SBAU4CM	6.25	0.43	0.088	17.5	50.8	218.3	1660	159	0.78	8.9
	RCSP5	6.49	0.31	0.086	8.0	48.8	67.0	1385	200	0.81	9.4
	TOSU5CM	7.14	0.48	0.104	28.2	92.4	98.8	1827	197	0.78	7.5
	SBAU5CM	7.47	0.17	0.094	12.8	64.8	100.6	2108	225	–	–
10	TOSU4M	5.93	0.15	0.072	–	43.8	46.5	1122	134	0.73	10.1
	SBAU4	5.21	0.54	0.081	23.4	45.5	220.8	1368	124	0.71	8.7
	RCSP5	6.14	0.27	0.072	7.4	42.2	50.7	1077	199	0.71	9.9
	TOSU5M	7.01	0.36	0.080	18.1	59.0	47.1	1434	190	0.64	7.9
	SBAU5	7.31	0.21	0.086	15.1	48.4	63.2	1523	210	–	–

[z] – = not determined. [y] The first two letters = crop name; the next two letters = season; the last numeral = planting year. Crop abbreviations: TO = tomato, RC = rice, MB = mungbean, SB = soybean, BW = buckwheat, CO = corn, CC = Chinese cabbage, SP = sweet potato. Season abbreviations: SP = spring, SU = summer, AU = autumn. [x] T-N = total nitrogen; inorganic N = NH_4-N + NO_3-N; Ava. P = available phosphorus.

Fluctuation of soil-available magnesium (Mg) associated with cultivation of different crops at different planting times was much smaller than that of other nutrients. Under the fixed cropping sequence (T-MB-CC), however, Mg increased from summer planting continuously up to spring planting and decreased after summer planting again. In the T-SB-R cropping sequence, the Mg level was still high after summer tomato, because fertilizer used for both the spring and summer crops in this rotation contained 4% MgO.

Nutrient uptake. Nitrogen uptake by various crops cultivated under different cropping sequences is presented in Table 9. N uptake by the same crop in the different crop rotations was very similar to each other. SB absorbed more than seven times as much N as the N fertilizer applied.

Table 9. Nutrition uptake of crops cultivated under different cropping sequences, spring 1985.

Rotation No.	Crops	N Uptake	P Uptake	K Uptake	Ca Uptake	Mg Uptake
1	Rice Root	4.5	0.9	5.3	0.1	0.6
	Stem	24.8	6.0	59.0	12.6	5.8
	Seed	47.9	12.4	8.7	0.4	5.2
	Total	77.2	19.3	72.9	13.2	11.6
9	Rice Root	3.1	0.4	3.2	0.3	2.4
	Stem	20.7	5.0	45.3	9.1	3.6
	Seed	44.5	12.6	9.0	0.5	5.1
	Total	68.3	18.0	57.4	10.0	11.1
10	Rice Root	2.5	0.6	2.3	0.3	1.7
	Stem	16.9	3.7	34.5	7.4	3.5
	Seed	40.2	10.4	7.2	0.3	4.2
	Total	59.5	14.7	44.0	8.1	9.4
2	MB Root	0.6	0.1	0.3	0.3	0.2
	Stem	1.8	0.3	1.9	1.5	1.0
	Leaf	3.5	0.3	1.0	4.9	1.1
	Pod	1.0	0.1	1.5	0.8	0.8
	Seed	14.8	1.6	3.1	0.2	0.6
	Total	21.7	2.3	7.9	7.6	3.7
3	SB Root	2.5	0.4	0.6	0.8	0.5
	Stem	12.5	4.5	7.2	32.9	12.5
	Leaf	22.2	2.8	3.8	49.0	8.7
	Pod	11.6	1.6	17.3	9.7	6.6
	Seed	248.1	23.6	41.4	8.5	10.3
	Total	296.8	32.9	70.3	100.9	38.5
5	SB Root	3.1	0.6	1.0	1.2	0.6
	Stem	16.5	5.2	7.5	37.4	14.0
	Leaf	39.2	2.5	4.6	66.4	11.0
	Pod	12.3	1.5	18.1	9.9	6.9
	Seed	238.9	22.5	40.3	5.2	9.5
	Total	310.0	32.2	71.4	120.1	42.0
4	TO Root	1.0	0.1	0.6	1.5	0.3
	Stem	13.6	1.5	7.6	40.1	11.2
	Leaf	27.4	3.9	4.9	76.5	10.2
	Fruit	80.0	12.2	61.3	12.6	5.7
	Total	122.0	17.8	74.5	130.8	27.3
6	CC Root	1.2	0.3	0.7	0.2	0.1
	Inner Leaf	28.6	4.4	12.8	2.9	1.2
	Outer Leaf	39.2	5.2	20.2	36.8	3.7
	Total	69.0	9.9	33.7	39.9	4.9
7	CC Root	1.2	0.3	0.9	0.3	0.1
	Inner Leaf	53.5	9.5	29.4	6.5	2.7
	Outer leaf	63.1	9.6	43.1	62.1	5.4
	Total	117.9	19.4	73.4	68.9	8.2
8	CC Root	1.0	0.3	0.7	0.2	0.1
	Inner Leaf	29.7	4.9	14.4	3.5	1.4
	Outer Leaf	41.3	6.4	26.4	38.8	3.9
	Total	72.0	11.5	41.6	42.4	5.3

SB took up nearly 90 kg P/ha while other crops absorbed only a half of it. MB showed the lowest uptake of P. SB showed the greatest K uptake, followed by CC and tomato. Rice absorbed nearly

50 kg K/ha and MB was lowest in K absorption. Ca uptake was very great in SB and tomato, and relatively high in CC. A sizable amount of Ca was changed to bioavailable forms or supplied by irrigation water. Mg uptake was greatest in SB and tomato showed the next largest absorption of Mg.

The acceptability of each rotation tested is shown in Table 10. Recommended cropping systems for legumes and vegetables are summarized in Table 11.

Table 10. Rotation system evaluation.

Rotation No.	Crops	Acceptability[z]	Remarks
1	R-MB-T	O	Each crop is introduced in place of MB.
2	MB-R-SP	x	Spring MB is not acceptable. R and SP also decreased their yield gradually.
3	SB-CC-BW	o	Buckwheat can be replaced by gramineous cash crops, like corn. For summer CC, introduction of new cultivar better than ASVEG or high pot cultivation are recommended.
4	T-CO-SB	O	All the rotation components have long durations. Early maturing tomato and corn cultivars are needed.
5	SB-SP-CC	v	CC showed N-deficiency symptoms. SP yield decreased greatly in the second cultivation.
6	CC-T-MB	x	Autumn MB should be changed to SB. Mulching is a key technique to summer tomato.
7	CC-T-MB (Mulch + Comp) (Mulch + Comp)	x	Autumn MB should be changed to SB.
8	CC-T-MB (Mulch) (Mulch)	x	Autumn MB should be changed to SB.
9	R-T-SB (Mulch + Comp)	v	Summer tomato following spring rice is risky because of poor drainage.
10	R-T-SB (Mulch)	v	Same as above

[z]O = highly acceptable, o = acceptable, v = acceptable but risky, x = not acceptable.

Table 11. Recommended cropping systems for legumes and vegetables.[z]

Rotation No.	Spring	N Applied[y] (kg/ha)	Summer	N Applied[y] (kg/ha)	Autumn	N Applied[y] (kg/ha)
1	R	50	MB (V1973A)	30	T (PT870, TK77, TM103)	120
2	SB (AGS129)	60	R	60	SP (CN1108-13)	80
3	SB (AGS129)	50	CC (ASVEG#9, 82-157)	100	BW(CO)[x]	50
4	T 110 CC (CL5915-159, -223)	110	CO (Tainan351, Tainan6)	50	SB (KS8)	40
5	CC (Bing-Luh)	100	T (CL5915-153)	60	SB (KS8)	40
6	CC (Compost added) (Bing-Luh)	100	T (Compost added) (CL5915-153)	80	SB (KS8)	20
7	R	40	SB (AGS66)	40	T (TK77, PT870, TM103)	120
8	SB (AGS129)	40	R	40	T (TK77, TM103, PT870)	120
9	R - SB - T - CC - R - SB (two years rotation)					
10	R - CC - SB - CO - R - T (two years rotation)					

[z]R - rice, SB - soybean, T - tomato, CC - Chinese cabbage, MB - mungbean, CO - corn, SP - sweet potato, BW - buckwheat. Cultivars enclosed in parentheses are recommended ones. [y]Total nitrogen application per year to each rotation is 200 kg/ha. [x]Either crop (buckwheat - BW or corn - CO) can be used.

Conclusion

In addition to these recommended rotation systems, the following should be considered in developing crop rotations: potential for maximum profit and yield, minimum input, and mechanization; adaptability to hazardous environments; self-sustaining; and nutrition-oriented.

Effect of Ca Foliar Spray, N Split-Application, Covering, and Water Management on Chinese Cabbage Tipburn and Internal Rot

Introduction

Soil science at AVRDC has confirmed that ammonium toxicity is a primary factor in Chinese cabbage tipburn. It was also clarified that at head-initiation time, cabbage was very susceptible to tipburn; therefore, NH_4-N application at this stage should be avoided. Internal rot, on the other hand, occurs even in plants fertilized with NO_3-N; hence, a different control mechanism should be considered for this physiological disorder. A series of experiments was, therefore, conducted that focused on cultural practices to minimize their incidence.

Materials and Methods

Greenhouse and pit experiments. Six experiments were conducted from summer 1984 to autumn 1985 in the greenhouse or in the pit. In experiment 1, the split-plot design with two replications was adopted with cultivar as the main plot treatment and foliar spray and covering as the subplot treatments (Table 12). Seedlings of either Fong-Luh or ASVEG 1 were transplanted to a plastic container, 50 × 35 × 30 cm^3 (soil depth was 20 cm) on 30 October for ASVEG 1 and 2 November for Fong-Luh. Harvest was on 11 and 14 December for ASVEG 1 and for Fong-Luh, respectively.

In experiment 2 (late autumn 1984), a sand culture experiment was conducted on a split-split plot design, in which cultivar was the main plot treatment, NH_4-N:NO_3-N ratio as subplot, and foliar spray of Ca-salts as sub-subplot treatments (Table 13). ASVEG 1 and Fong-Luh were transplanted on the same day (16 November 1984), but harvested separately on 4 and 11 January 1985, respectively.

Table 12. Effect of covering and foliar spray on Chinese cabbage tipburn and internal rot (experiment 1, autumn 1984).

Treatment	Fong-Luh[z]			ASVEG 1[z]	
	head wt	tipburn rot	internal rot	head wt	internal rot
1. Liquid NH_4-N	939.0 ab			864.4 a	
2. Liquid NO_3-N	1049.0 a			912.2 a	
3. Solid NH_4-N [y]	656.5 bc	***		675.4 ab	***
4. Covering BHF	631.0 bc	*	*	719.3 ab	**
5. Covering AHF[x]	359.0 c	****		565.3 b	**
6. Covering BAHF[w]	528.0 bc	***	*	573.2 b	**
7. Covering AHF + Ca-cit FS[v]	448.5 bc	*****		533.4 b	***
8. Covering + Ca-cit FS, AHF	468.5 bc	****		475.7 b	***
9. Ca-cit FS	646.5 bc	*****		800.9 ab	**
10. $CaCl_2$ FS	686.5 b	******		550.9 b	****
11 Citric acid FS	801.5 ab		**	810.3 ab	**
12. Water FS	572.5 bc	*		776.1 ab	**
LSD (.05)	251.6			251.6	

[z]Symbols indicate the relative extent of tipburn and internal rot damage: * = very slight; ** = slight; ***, **** = medium; ***** = severe; ****** = very severe. Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]Before head formation. [x]After head formation. [w]Before and after head formation. [v]Ca-citrate foliar spray: 50 ml/pot of Ca-citrate at a concentration of 0.0005 M is sprayed twice a week over the whole period of growth.

Table 13. Effect of N form and Ca foliar spray on Chinese cabbage tipburn and internal rot (experiment 2, sand culture, autumn 1984).

	Treatment			Fong-Luh[z]		ASVEG 1[z]		
	NH_4:NO_3[y]	Ca (ppm)[x]	foliar spray[x]	head wt[w]	tipburn[v]	head wt[w]	tipburn[v]	inter. rot[v]
1	7 : 1	160	Ca-citrate	249.1 d	0	213.2 c	0.25	0.75
2	7 : 1	160	$CaCl_2$	160.4 e	1	309.2 c	0.75	0.25
3	7 : 1	160	–	214.4 de	2	279.7 c	2.00	0.25
4	7 : 1	0	–	56.1 f	4	205.5 c	3.50	1.75
5	1 : 7	160	Ca-citrate	906.4 b	0	788.4 ab	0	1.50
6	1 : 7	160	$CaCl_2$	909.3 b	0	710.7 ab	0	1.50
7	1 : 7	160	–	980.7 a	0	829.1 a	0	2.25
8	1 : 7	0	–	810.5 c	0	660.8 b	0	3.00

[z]Main plot. [y]Subplot. [x]Sub-subplot. [w]Numbers having the same letter are not significantly different at the 5% level by DMRT. [v]Numerals indicate the relative extent of tipburn and internal rot damage. The damage increases as the number grows.

Experiment 3 was conducted in spring 1985 on a randomized complete block design with two replications. ASVEG 1 was transplanted on 2 April, and harvested on 8 May 1985 (Table 14). Experiment 4 was conducted in summer 1985 to examine the effect on tipburn of various soil mixtures to increase water-holding capacity. Seedlings of ASVEG 1 were transplanted on 27 June and harvested on 2 August 1985. Main plot treatment was $CaCl_2$ or Ca-citrate application. Subplot treatment was composed of 10 soil mixtures (Table 15).

In experiment 5, the effects of different cover materials and watering methods were evaluated on ASVEG 1 in 1985 (late summer) from 20 August to 24 September (Table 16). Experiment 6 was started on 21 October and harvested on 29 November 1985 (Table 17).

Field experiments. Three field experiments were carried out in 1985 (one in spring, two in summer) to confirm the results of preceding experiments. In experiment 1, seedlings of ASVEG 1 and Fong-Luh were transplanted to the field on 1 April and harvested on 15 May 1985. A split-split-plot design with two replications was adopted with main plots composed of three cover treatments (plastic sheet mulch, rice straw mulch, and transparent plastic roof). Other treatments were bed height (100, 70, and 40 cm) in the subplot and ASVEG 1 and Fong-Luh in the sub-subplots.

Experiment 2 was conducted to determine the effects of compost application and soil pH on yield and frequency of diseases. reatments were compost applications (0, 25, and 50 t/ha) in the main plot and soil pH (6, 5.5, 5, 4.5, and 7.3) in the subplot. ASVEG 1 was transplanted on 14 June and harvested on 25 July 1985.

In experiment 3, four heat-tolerant cultivars (ASVEG 1, Hybrid 82-157, 77M(3)-27, 77M(2)-35) were tested on their susceptibility to internal rot and tipburn (main plot). Other treatments were high pots in the subplot and fertilization in the sub-subplot. Seedlings were transplanted on 14 June 1985 and harvested on 22 and 30 July 1985.

Results and Discussion

Effect of foliar spray of Ca-salts and organic acids. In experiment 1, foliar spray of Ca-salts could not cure marginal rot in Fong-Luh (Table 12), and internal rot in ASVEG 1. Citric acid, however, increased the yield and significantly decreased the frequency of marginal rot in Fong-Luh. Thus, there was a great difference in the frequencies of marginal and internal rot between the two cultivars: Fong-Luh was more susceptible to marginal rot than the internal rot; the opposite was true of ASVEG 1.

There was no significant difference in nutrient distribution between cultivars. Foliar sprays did not change total N content in both the blade and the midrib. Citric acid spray, however, increased NO_3-N content in the head leaf significantly, and the water spray greatly increased Ca content in the leaf blade.

In experiment 2, results confirmed again that Chinese cabbage grown in a NO_3-N-dominant cultural solution (NH_4:NO_3 = 1:7) produced four times as much head weight as that grown in the NH_4-N dominant-one (NH_4:NO_3 = 7:1), regardless of the amount of Ca applied through the cultural solution and/or foliar spray (Table 13).

Table 14. Effect of nitrogen fertilization, foliar spray, and IGETAGEL application on Chinese cabbage internal rot (Variety: ASVEG 1, experiment 3, spring 1985).

Treatments:	Fertilization			Other Treatments	Total Wt[y] (g/plant)	Head Wt[y] (g/plant)	Internal Rot
	Basal	10 DAT[z]	20 DAT				
1	Liquid NO_3-N, 0.25 g N is applied twice a week			NO	1375 c	850 bcd	1.5
2	2-1.5-2.5	1-0-0		NO	1430 abc	905 abcd	2.5
3	3-1.5-2.5	1-0-0	1-0-0	NO	1680 ab	1047.5 ab	2
4	3-7.5-2.5	1-2.5-0	1-2.5-0[w]	NO	1525 abc	1042.5 ab	2
5	2-1.5-2.5	1-0-0		Foliar spray of Ca-citrate BHF[v]	1410 abc	897.5 abcd	2
6	"	"		FS Citrate BHF	1500 abc	952.5 abcd	1.5
7	"	"		FS Malate BHF	1690 a	1005 abc	2
8	"	"		Covering BHF	1395 bc	770 de	0
9	"	"		Leaf tying BHF	1095 d	587.5 e	0
10	"	"		IGETAGEL (5%)[u]	1420 abc	802.5 cd	2
11	"	"		" (2%)	1440 abc	900 abcd	2
12	3-7.5-2.5	1-2.5-0	1-2.5-0	" (5%)	1645 abc	1085 a	1.5
	LSD				259	190	

[z]Days after transplanting. Transplanted on April 2, 1985, harvested on May 8, 1985. [y]Numbers having the same letter are not significantly different at the 5% level by DMRT. [x]Numerals indicate the relative extent of internal rot damage. [w]N and P are applied together in the form of $(NH_4)_2HPO_4$. [v]Ca-citrate foliar spray before head formation. [u]IGETAGEL is mixed with soil mass (15 cm diam. x 10 cm depth) prior to seedling transplanting.

Table 15. Effect on Chinese cabbage tipburn and internal rot of Ca-chelate application and increased water-holding capacity of the soil (by material incorporation) (experiment 4, summer 1985).

Treatment	Total Wt[z] (g/plant)	Head Wt[z] (g/plant)	Extent of[y]	
			tipburn	intern. rot
Main Plot: 1. $CaCl_2$	1069.6a	401.2a	1.1	2.4
2. Ca-citrate	1058.8a	442.9a		
LSD (0.05)	1949.3	1427.7		
Subplot: 1. Check	1015.5a	386.5a	1.5	2.2
2. SRH	1071.3a	388.4a	2.5	5.0
3. Quartz sand	1188.8a	557.5a	2.0	4.5
4. Gypsum granular	1101.1a	501.3a	1.5	4.0
5. Vermiculite	1104.6a	403.9a	3.5	4.5
6. Compost	1025.5a	322.4a	3.5	6.0
7. IGETAGEL, 1%	884.2a	332.7a	2.0	4.5
8. " , 2%	1127 2a	485.2a	2.0	4.5
9. " , 5%	1015.3a	420.0a	2.0	4.0
10. " , 7.5%	1108.5a	422.8a	3.5	4.0
LSD (0.05)	370.7	286.8	1.5	5.0

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]Numbers listed are relative extent value of tipburn and internal rot. The higher the value, the more severe the symptoms.

Table 16. Experimental design for experiment 5.[z]

Treatment No.	Materials Added[y]	Covering[x]	Irrigation Pipe[w]	Fertilizer[v]	Boric Acid[u]
1	GG	No	*	Solid	No
2	GG	"	"	"	Yes
3		red film 2	"	"	"
4		blue film 2	"	"	"
5		rice straw 2	"	"	"
6	QS	No	"	"	No
7	QS	"	"	"	Yes
8	QS	red film 2	"	"	"
9	QS	blue film 2	"	"	"
10	QS	rice straw 2	"	"	"
11	NO	red film 1	**	"	"
12	"	" 2	"	"	"
13	"	blue film 1	"	"	"
14	"	" 2	"	"	"
15	"	rice straw 1	"	"	"
16	"	" 2	"	"	"
17	"	No	** 2 pipes at 10, 20 cm	"	No
18	"	"	** 2 pipes at 10, 20 cm	"	"
19	"	"	** 1 pipe at 10 cm	"	"
20	"	"	** 1 pipe at 20 cm	"	"
21	"	"	Yes*	Liquid	"
22	GG	"	"	"	"
23	QS	"	"	"	"
24	NO	No	*	Solid	"

[z]Transplanted on 20 Aug. 1985 and harvested on 24 Sept. 1985. [y]GG = gypsum granule, QS = quartz sand. These materials were mixed with soil at the ratio of 2 to 50 by weight. [x]Red film 1 = plant is covered with red plastic film for 2 wk from 1 wk after transplanting (28 Aug. to 11 Sept.); red film 2 = covered for 2 wk from 2 wk after transplanting (4-19 Sept.); blue film = covered with blue plastic film; rice straw = outer leaves of plant were covered with rice straw; numerals following cover materials have the same meaning as that for the red film treatment. [w]* = ordinary watering; ** = through an irrigation pipe buried at the depth of either 10 cm or 20 cm. [v]Solid = solid fertilizer (N-P_2O_5-K_2O, g/pot) was applied in the following ratio: 1.0-1.5-1.0 (basal); 1.0-0-1.0 (top 1, 10 DAT); 1.0-0-0 (top 2, 20 DAT). Liquid = 0.25 g N dissolved in distilled water applied 3 times a week. All the P and K were added as basal fertilizer. [u]Boric: Yes = 500 mg of boric acid is added to each plant; No = none applied.

Table 17. Effects of covering, irrigation methods and fertilizer form on internal rot in ASVEG 1 and hybrid 82-157 (experiment 6, autumn 1985).

	Treatment[z] (covering, pipe, fertilizer)	ASVEG 1[y] head wt	ASVEG 1[y] intern. rot	Hybrid 82-157[y] head wt	Hybrid 82-157[y] intern. rot
1.	Red film, no pipe, Solid $(NH_4)_2SO_4$	872.5 ef	***	749.0 bc	*
2.	" , 2 pipes, "	913.5 def		696.5 c	
3.	" , " , Liquid $NaNO_3$	1101.5 abc		765.0 abc	
4.	Yellow, no pipe, Solid $(NH_4)_2SO_4$	801.0 f	***	850.0 ab	
5.	" , 2 pipes, "	989.0 cde		733.0 bc	*
6.	" , " , Liquid $NaNO_3$	1006.0 bcde		867.0 ab	
7.	No , 1 pipe, 0.25 g $(NH_4)_2SO_4$	1034.0 bcd		770.0 abc	*
8.	" , " , 0.25 g $(NH_4)_2HPO_4$	970.0 cde		817.0 abc	*
9.	" , " , 0.25 g $NaNO_3$	1147.0 ab		874.0 ab	
10.	" , " , 0.75 g $(NH_4)_2SO_4$	1206.0 a		904.0 a	
11.	" , " , 0.75 g $(NH_4)_2HPO_4$	1062.5 abcd		849.5 ab	
12.	" , " , Solid $(NH_4)_2SO_4$	1155.0 ab		815.5 abc	****
LSD (.05)		150.7		150.7	

[z]Subplot: Covering = red or yellow plastic film for 2 wk from 1 wk after transplanting. Irrigation pipe = for 2 pipes, one was buried 10 cm deep from transplanting to head formation, and the other, 20 cm after head formation; for 1 pipe, it was buried 10 cm deep throughout the growth period. Ordinary watering was done when no pipe was used. Solid fertilizer = N-P_2O_5-K_2O, g/pot (basal) 2.0-1.5-2.0 (top 10 DAT), 1.0-0-0 (top). Liquid fertilizer = 0.25 g $NaNO_3$ dissolved in water and applied 3 times a week through the irrigation pipe. P_2O_5 and K_2O were applied as basal fertilizer at the ratio of 1.5 g and 2.0 g/pot, respectively. Liquid 0.25 $(NH_4)_2SO_4$; same as above except for the nitrogen form. Liquid 0.25 $(NH_4)_2HPO_4$ = same as above, but only K_2O is applied as basal fertilizer. Liquid 0.75 $NaNO_3$; dissolved in water and applied once a week through the irrigation pipe. [y]Main plot: cultivar.

Ca application significantly increased head weight. Foliar spray of Ca-salts eased tipburn in both cultivars. Ca-citrate was more effective against it than $CaCl_2$ in the plants with serious damage by NH_4-N toxicity. The Ca foliar spray also eased internal rot (only slightly in ASVEG 1) and this was mainly due to change in the head type of ASVEG 1 (from round to long shape). Tipburn occurred only in the plants grown in the NH_4-N dominant solution in both cultivars, while internal rot was found only in ASVEG 1. However, it occurred even in the NO_3-N dominant solution. Thus, it is confirmed that different factors affect tipburn and internal rot, and that internal rot is closely related to the type of cabbage head.

In experiment 3, foliar citrate spray reduced internal rot, but malic acid and Ca-citrate did not (Table 14). Citric acid is a strong legand and forms chelate-compounds with Ca after penetrating plant tissues to convert insoluble Ca-compounds to water-soluble forms, thus, making Ca easily translocated to the head leaves. Malate, on the other hand, is a weak chelator; so, it cannot dissolve a sufficient amount of the insoluble Ca compounds which, therefore, cannot be translocated to the head leaves.

As noted, ASVEG 1 was very susceptible to internal rot, but Fong-Luh was not. Fong-Luh possessed a long head composed of many leaves with equal weights and similar upward growth rates. ASVEG1 is composed of few, rather heavy, thick leaves. The inner leaves close in upon themselves in the shape of a balloon, thus, producing a pressure that is not easily released upward as in Fong-Luh. Therefore, an increase in nitrogen and compost rates, temperature, and water supply results in a fast growth rate that exerts a strong physical pressure inside the head, creating a condition conducive to internal rot.

The Ca foliar spray affected the N/Ca ratio of the heading leaves and delayed heading time, thus, resulting in a change of head shape from round to long, and the release of inner pressure upward.

Effect of N split-application on tipburn and internal rot. In experiment 1, split-application of liquid nitrogen produced the heaviest head without any symptoms of tipburn and internal rots (treatments 1 to 3, Table 12) because it did not increase nitrogen concentration steeply; and so, NH_4-N toxicity was avoided, and the initial vigorous growth of heads was suppressed.

Split-application of liquid N increased Ca content in the head leaves (Table 18). The outer leaves had Ca content 10 to 20 times higher than that in the head leaves, indicating that activity was kept higher in the former even after head formation. Therefore, high Ca content is associated with the active transpiration rate in the outer leaves. NO_3-N content in the head leaves was also increased greatly, especially by split application of liquid NO_3-N. The high N content in leaves keeps the leaves active for photosynthesis and delays senescence of the plants.

Since the split-application of N decreased the frequency of internal rot and tipburn in the autumn trial, further fertilizer trial (experiment 3) was conducted in the spring (Table 14).

Application of 3 g N/plant as basal fertilizer stimulated initial growth and resulted in great total and head weights. However, the plants suffered from serious internal rot. Although N split-application slightly eased internal rot, it could not be eliminated completely, as in the autumn trial. In the spring both temperature and light intensity went up steeply from head initiation time.

Even if N split-application was conducted, nitrogen gradually accumulated in the pot because there was no drainage. Therefore, high temperature accompanied by high light intensity accelerated inner leaf growth rate after head formation, thus, nitrogen greatly induced tipburn and internal rot which could not be completely controlled.

Accordingly, heavy application of N at late growth stage aggravated tipburn and internal rot. Also, heavy N basal dressing caused great yield loss, tipburn in Fong-Luh, and internal rot in ASVEG 1. So, it is very important to suppress both a vigorous initial growth and late growth while keeping the leaves active throughout the growth stage in terms of nitrogen application.

Regulation of plant growth rate by covering. Several experiments were conducted to examine the effect on tipburn and internal rot incidence of plant covers of various materials at different growth periods.

In the autumn trial (experiment 1), the outer leaves were covered with black vinyl sheet from transplanting to head formation. This treatment resulted in higher yield than in any other treatments, and decreased frequency of marginal rot, but not of internal rot. Covering after the head-formation stage caused a great decrease in head weight and aggravated both marginal and internal rots. Covering seems to be a promising technique to suppress initial plant growth to minimize marginal rot.

Table 18. Effect of N split application, covering, and foliar spray on nutrient distribution in Chinese cabbage, autumn 1984.[z]

Treatment	Head Leaf Blade (%)				Head Leaf Midrib (%)			
	Total-N	NH_4-N	NO_3-N	Ca	Total-N	NH_4-N	NO_3-N	Ca
Main Plot: Cultivar								
1. Fong-Luh	4.804 a	0.098 a	0.088 a	0.230 a	2.866 a	0.030 a	0.288 b	0.650 a
2. ASVEG 1	4.862 a	0.083 a	0.120 a	0.178 a	2.976 a	0.026 a	0.368 a	0.591 a
LSD (0.05)	0.160	0.073	0.205	0.090	0.549	0.042	0.061	0.363
Subplot: Countermeasures to avoid internal rot								
1. Liquid NH_4-N	4.617 de	0.080 cde	0.074 cde	0.226 ab	2.799 cd	0.019 bcd	0.249 de	0.613 abc
2. Liquid NO_3-N	4.491 de	0.065 de	0.211 a	0.261 ab	2.628 cd	0.030 bcd	0.547 abc	0.619 abc
3. Solid NH_4-N	4.277 e	0.051 e	0.051 e	0.185 ab	2.171 d	0.013 cd	0.139 e	0.525 c
4. Covering BHF	4.237 e	0.049 e	0.078 cde	0.183 ab	2.291 cd	0.011 d	0.252 de	0.559 bc
5. Covering AHF	5.274 bc	0.109 bcd	0.093 cde	0.160 b	3.458 ab	0.038 abcd	0.319 cde	0.610 abc
6. Covering BAHF	5.404 ab	0.120 abc	0.124 bcd	0.206 ab	3.655 a	0.044 abc	0.715 a	0.774 a
7. Covering AHF + Ca-cit FS	5.680 ab	0.154 ab	0.155 b	0.218 ab	3.915 a	0.065 a	0.478 bcd	0.776 a
8. Covering + Ca-cit FS, AHF	5.882 a	0.165 a	0.151 b	0.191 ab	3.965 a	0.049 ab	0.594 ab	0.724 ab
9. Ca-cit FS	4.186 e	0.057 e	0.043 e	0.145 b	2.261 cd	0.011 d	0.091 e	0.493 c
10. $CaCl_2$ FS	4.514 de	0.062 de	0.072 cde	0.176 b	2.525 cd	0.012 cd	0.174 e	0.526 bc
11. Citric acid	4.617 de	0.085 cde	0.126 bc	0.178 b	2.848 bc	0.019 bcd	0.232 e	0.619 abc
12. Water FS	4.817 cd	0.083 cde	0.069 de	0.319 a	2.540 cd	0.021 bcd	0.146 e	0.605 abc
LSD (.05)	0.498	0.051	0.056	0.138	0.656	0.032	0.231	0.198

[z]Pot experiment. Numbers having the same letter are not significantly different at the 5% level by DMRT.

In experiment 3, covering or leaf-tying before the head formation stage completely eliminated internal rot, but total and head weights decreased greatly.

In experiment 5, the plants were completely covered with colored films 30 cm above the plant at one week or two weeks after transplanting (Table 16). The rice straw cover was placed on the outer leaves only. The blue film cover resulted in significantly great yield loss, aggravated marginal rot, but completely eliminated internal rot. The red film and rice straw covers greatly decreased both incidences (Table 19). The latter can also be used again. Covering should be done one week after transplanting up to head-formation stage.

Table 19. Effect of covering materials, watering method, and boron on Chinese cabbage, late summer 1985.[z]

Treatment	Total Weight	Head Weight	Marginal Rot	Internal Rot
1. Red 2, borate	1020 hi	435 f	*	
2. Red 2, borate, QS	1015 hi	460 ef	***	
3. Red 2, borate, pipe	1060 ghi	520 def		*
4. Red 1, borate, pipe	1165 fgh	555 def		
5. Blue 2, borate	630 k	205 g	***	
6. Blue 2, borate, QS	720 jk	230 g	***	
7. Blue 2, borate, pipe	685 jk	225 g	***	
8. Blue 1, borate, pipe	870 ij	215 g		
9. Rice straw 2, borate	1220 fgh	550 def	*	
10. Rice straw 2, borate, QS	1215 fgh	545 def		
11. Rice straw 2, borate, pipe	1285 efg	690 bcd		*
12. Rice straw 1, borate, pipe	1210 fgh	560 def		
13. Quartz sand	1355 cdef	740 bcd		*
14. Quartz sand, borate	1495 abcde	700 bcd	*	**
15. Gypsum granule	1230 fgh	615 def		**
16. Gypsum granule, borate	1290 efg	665 cde	**	**
17. Pipe at 10 cm	1525 abcd	855 abc		*
18. Pipe at 20 cm	1575 abc	855 abc		*
19. 2 pipes at 10, 20 cm	1605 a	965 a		*
20. 2 pipes at 10, 20 cm, borate	1590 ab	905 ab		*
21. Pipe, liquid-F	1600 a	955 a		*
22. Pipe, liquid-F, GG	1480 abcde	730 bcd		**
23. Pipe, liquid-F, QS	1365 bcdef	670 cde		*
24. Check	1310 def	610 def		***

[z]Experiment 5. Asterisks indicate the relative extent of damage by marginal and internal rots: * = slight damage; *** = severe damage. Numbers having the same letter are not significantly different at the 5% level by DMRT.

Irrigation through pipes buried 10 cm or 20 cm deep effectively decreased tipburn and internal rot. Initial growth was slightly retarded before the water reached the plant roots; but from then on, this watering method accelerated root development and minimized incidence.

In experiment 6, combining the red or yellow film covers with buried pipe irrigation completely controlled internal rot (Table 17). Growth rate can be suppressed by covering or enhanced by N and water applications at the desired time to eliminate tipburn and internal rot without a great decrease in yield.

Effect of water management on tipburn and internal rot. Tipburn was a result of root damage by NH_4-N; so, the maintenance of enough root mass was extremely important to eliminate the incidence. In this experiment, all the plants suffered from serious internal rot and tipburn, despite the incorporation of various materials considered capable of increasing the water-holding capacity of the soil (Table 15). Increasing the water-holding capacity of the soil with a limited root mass failed to cure tipburn. As a result, soil moisture fluctuation in the medium was greater than that in the original soil.

On the other hand, the buried-pipe irrigation enhanced rooting and regulated growth rate. The irrigation pipe buried 10 cm deep from transplanting to head formation, and 20 cm deep after head formation produced the heaviest head (Table 19). The combination of pipe irrigation and N split-application through the pipe or covering gave heavy heads without any symptoms (Table 17).

The fertilizer $NaNO_3$ gave the heaviest head, followed by $(NH_4)_2SO_4$; $(NH_4)_2HPO_4$ gave the smallest. Head weight of hybrid 82-157 was not influenced significantly. Applying fertilizer through a pipe together with irrigation water is a superior technique. Nitrogen can be distributed more evenly in the soil, thus, avoiding N localization and decreasing internal rot.

Field experiments. In experiment 1, bed height did not affect Chinese cabbage yield and the frequency of internal rot and tipburn, indicating that the 40-cm raised bed was high enough for practical use in spring (Table 20). ASVEG 1 was more susceptible to internal rot but more tolerant to tipburn than Fong-Luh.

In experiment 2, compost application aggravated internal rot of ASVEG 1 (Table 21). Hence, compost should not be applied to Chinese cabbage in the summer. Compost application accompanied by deep plowing also caused serious flood damage in the rainy season.

Soil pH, except pH 4.5, did not affect the frequency of internal rot. Soil pH 4.5 caused serious retardation of initial growth and decreased yield greatly. Low soil pH may increase Ca availability in the soil, but cannot cure internal rot.

In experiment 3, Hybrid 82-157 escaped internal rot (Table 22). This cultivar possesses slightly smaller and less compact heads than ASVEG 1. This means that head type is very important in relation to internal rot. N split-application decreased internal rot. The results of the three field experiments confirmed those obtained in the greenhouse and pit experiments.

In 1984-85, six pot experiments and three field tests were conducted aimed at minimizing Chinese cabbage tipburn and internal rot through the use of a number of cultural practices. These practices included foliar sprays of Ca-salts and organic acids, N split-application, covering of outer leaves or leaf-tying, use of the right cultivar and soil medium, compost and fertilizer application, mulching (plastic sheet, rice straw, and a transparent plastic roof), high pots, and buried pipe irrigation.

Based on the results of these experiments and previous tests, the factors responsible for the incidences of these two physiological disorders were determined and their respective countermeasures identified (Table 23).

Conclusion

Ca foliar spray, N split-application, covering of leaves, underground pipe irrigation, and the use of the right cultivars and media all contribute to the control of internal rot and tipburn, depending on the factors causing the physiological disorder of the Chinese cabbage plants.

Adequate Seedling Medium for Tomato and Chinese Cabbage

Introduction

Healthy seedlings contribute highly to good vegetable yield, and seedling quality is chiefly decided by the soil medium. This project aimed to develop an adequate seedling medium for tomato and Chinese cabbage by using available local materials.

Materials and Methods

The tomato seedling treatments (summer) consisted of the following: main plot-compost materials (sugarcane, mushroom, rice straw); subplot—composition ratios of soil, compost, and smoked rice hull; sub-subplot—NPK application. The treatments after transplanting were as follows: main plot—rain shelter (with and without); subplot—different seedling mediums.

Table 20. Effects of covering materials and bed height on yield and frequency of internal rot and tipburn, spring 1985.[z]

Treatment	Yield (t/ha)		Frequency of Disease[y] (%)				
	marketable	total	internal rot (* *)	internal rot (*)	tipburn	soft rot	healthy
Main Plot							
1. Roof	19.56 b	46.47 a	31.8 a	13.6 b	11.1 a	13.7 a	29.8 b
2. Plastic mulch	29.42 a	56.56 a	25.8 a	27.0 a	5.0 ab	10.8 a	29.5 b
3. Rice straw mulch	36.96 a	59.40 a	16.9 a	21.6 ab	0 b	4.9 a	56.6 a
LSD (0.05)	9.20	15.5	17.0	12.0	10.1	8.68	24.4
Subplot							
1. 100 cm bed	27.73 a	53.29 ab	29.0 a	20.3 a	7.1 a	9.3 a	34.2 a
2. 70 cm bed	27.03 a	52.30 b	27.3 a	18.0 a	5.7 a	8.9 a	38.2 a
3. 40 cm bed	31.17 a	56.84 a	18.3 a	23.9 a	3.2 a	11.2 a	43.5 a
LSD (0.05)	4.28	4.12	14.3	12.9	4.06	9.65	16.6
Sub-Subplot							
1. ASVEG 1	29.37 a	47.41 b	33.2 a	25.6 a	0.9 b	5.6 b	34.7 a
2. Fong-Luh	27.92 a	60.88 a	16.6 b	15.9 a	9.8 a	14.0 a	42.5 a
LSD (0.05)	2.12	2.22	12.1	15.3	2.79	3.62	20.2

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]* * = more damage, * = slight damage.

Table 21. Effects of compost application and soil pH on yield and frequency of internal rot and tipburn, summer 1985.[z]

Treatment	Yield (t/ha)		Frequency of Disease[y] (%)				
	marketable	total	internal rot (* *)	internal rot (*)	tipburn	soft rot	healthy
Main Plot							
1. Compost 50 t/ha	21.86 a	39.28 a	25.01 a	51.91 a	0.19 a	0 a	22.89 a
2. " 25 t/ha	20.86 a	36.89 a	32.99 a	45.75 b	0 a	0.19 a	21.07 a
3. " 0 t/ha	22.18 a	39.81 a	27.66 a	37.97 c	0 a	0 a	34.36 a
LSD (0.05)	8.10	10.7	44.2	2.67	0.67	0.67	41.0
Subplot							
1. pH 6.0	24.59 ab	42.44 a	34.05 a	44.40 a	0.32 a	0 a	21.22 b
2. pH 5.5	25.26 a	42.79 a	35.85 a	47.05 a	0 a	0 a	17.10 b
3. pH 5.0	21.48 b	40.26 a	37.03 a	46.18 a	0 a	0.32 a	16.47 b
4. pH 4.5	13.31 c	26.93 b	8.32 b	41.12 a	0 a	0 a	50.57 a
5. Check	23.52 ab	40.88 a	27.52 a	47.30 a	0 a	0 a	25.18 b
LSD (0.05)	3.00	5.64	16.1	11.0	0.44	0.44	13.0

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]* * = more damage, * = slight damage.

Table 22. Effects of cultivar, high seedling pot, and fertilization on yield and frequency of internal rot and tipburn, summer 1985.[z]

Treatment	Yield (t/ha)		Frequency of Disease (%)				
	marketable	total	internal rot (**)[y]	internal (*)[x]	tipburn	soft rot	healthy
Main Plot							
1. ASVEG 1	29.49 a	50.44 a	24.13 b	43.19 a	0 a	0 a	32.69 b
2. Hybrid 82-157	22.22 a	44.57 a	0.36 c	9.75 b	0.36 a	0 a	89.53 a
3. 77M(3)-27	26.44 a	47.06 a	51.66 a	26.61 ab	0.7 a	0.71 a	20.31 b
4. 77M(2)-35	26.63 a	49.73 a	29.11 b	30.49 a	0 a	0.45 a	39.95 b
LSD (.05)	7.17	12.2	15.0	20.0	2.00	2.16	22.7
Subplot							
1. High pot	24.94 b	48.83 a	25.30 a	31.92 a	0.53 a	0.4 a	41.85 b
2. PE pot	27.45 a	47.07 a	27.33 a	23.10 a	0 a	0.18 a	49.39 a
LSD (.05)	2.01	4.48	13.3	10.2	1.09	0.62	6.32
Sub-Subplot							
1. F1[w]	26.01 a	48.40 a	20.16 b	25.39 a	0.53 a	0.18 a	53.74 a
2. F2	26.37 a	47.50 a	32.48 a	29.63 a	0 a	0.41 a	37.49 b
LSD (.05)	1.72	2.42	6.48	6.90	0.91	0.78	8.18

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]** = more damage; [x]* = slight damage.
[w]Treatments (N-P_2O_5-K_2O-Mg): F1 = 60-60-60-16 (basal), 60-60-60-16 (top); F2 = 120-80-100 (basal).

Table 23. Summary of countermeasures to minimize tipburn and internal rot.

Hazard	Factors[z]	Countermeasures
Internal Rot		
	1. limited Ca translocation	1. foliar spray of citric acid
	2. fast growth rate	1. covering outer leaf BHF 2. N split application 3. underground pipe irrigation
	3. balloon-head type	1. Ca foliar spray 2. selection of adequate cultivar
	4. decreased outer leaf activity	1. continuous N application
Tipburn		
	1. NH_4-N toxicity	1. avoid applying NH_4-N at head initiation time
	2. root damage	1. increase soil CEC 2. keep soil moisture constant 3. avoid heavy fertilization
	3. limited root mass	1. increase soil mass 2. enhance rooting by water management
	4. rapid initial growth	1. N split application 2. covering outer leaf with rice straw 3. underground pipe irrigation

[z]Factors causing the physiological disorders.

The Chinese cabbage treatments (summer) were the following: main plot—seedling management; subplot—different seedling mediums. In the autumn trial, the treatments consisted of the following: main plot—pot height (high and low); subplot—different seedling mediums.

The experiments were conducted in summer 1985 for Chinese cabbage and tomato, and in autumn 1985 for Chinese cabbage. Seedling mediums tested are summarized in Tables 24, 25, and 29.

Table 24. Treatments in the tomato experiment, summer 1985.

Main Plot	Subplot	Sub-Subplot
A. Treatments in seedling stage		
Compost Materials: sugarcane mushroom rice straw	Composition Ratio (soil:compost: smoked rice hull): 1:1:0 3:1:0 3:1:1 5:1:1 check (soil only)	Fertilizer Application: NPK 0 mg NPK 100 mg each/kg soil
B. Treatments after transplanting		
Rain Shelter: no yes	Seedling Medium: SCC 3:1:1 +N[z] (B1[y]) MRC 3:1:0 −N (B2) RSC 5:1:1 +N (B3) RSC 3:1:1 −N (U1) MRC 3:1:0 +N (U2) SCC 5:1:1 +N (U3) Check −N (Ck 1) Check +N (Ck 2)	

[z]From left, compost material (SCC: sugarcane, MRC: mushroom, RSC: rice straw), composition ratio (soil: compost:smoked rice hull) and fertilizer application (-N : NPK 0 mg, +N : NPK 100 mg each /kg soil).
[y]Two kinds of seedlings were chosen from the seedling-stage experiment transplanted for the field test: 1) those with the best growth (B1 to B3), 2) those with the best growth uniformity (U1 to U3).

Results and Discussion

Summer Chinese cabbage trial. The medium materials greatly affected the initial growth as well as the yield of Chinese cabbage (Table 25). Plants grown in the mixture of soil, sugarcane compost, and smoked rice hull at the ratio of 5:1:1 showed the highest yield, followed by those in the same mixture of a different ratio of 3:1:1. The sand-crotalaria mixture at the ratio of 1:2 seemed promising, but chlorosis due to iron deficiency caused by high pH appeared on the leaves. This medium should, therefore, be used together with a foliar spray.

Table 25. Effect of seedling medium on Chinese cabbage yield, summer 1985.

Treatment	Plant Weight at (g)		Yield (t/ha)	
	WAT 1[z]	WAT 2	marketable	total
Main Plot: Management Discipline				
1. CM[y]	11.8 a	52.6 a	16.22 a	30.96 a
2. SL	13.4 a	58.2 a	16.58 a	31.13 a
LSD (.05)	4.26	13.58	1.81	1.93
Subplot: Seedling Medium[x]				
1. M1; AVRDC standard mixture	2.5 d	13.0 d	10.37 d	21.52 c
2. M2; 1:2 (Sd:CLC)(CM)	12.2 b	62.6 bc	17.72 b	32.83 ab
3. M3; 2:4:1 (Sd:CLC:RH)(CM)	9.2 c	48.3 c	15.36 c	30.18 b
4. M4; 3:1:1 (Sl:SCC:SRH)(SL)	19.1 a	74.0 ab	18.52 ab	34.87 a
5. M5; 5:1:1 (Sl:SCC:SRH)(SL)	20.1 a	79.2 a	20.03 a	35.85 a
LSD (0.05)	1.91	15.69	2.02	3.09

[z]WAT = weeks after transplanting. [y]CM = Crop Management Dept. SL = Soil Science Dept.
[x]Sd = sand; CLC = crotalaria compost; RH = rice hulls; S1 = soil; SCC = sugarcane compost; SRH = smoked rice hulls.

Summer tomato trial. The results are summarized in Table 26. In the main plot, sugarcane compost (SCC) resulted in the highest germination rate (GR) at four days after sowing (DAS). In the subplot, the check (soil only) had the highest GR which decreased with the increasing ratio of compost to soil. In the sub-subplot, no difference in GR was found between fertilized and unfertilized plants at 7 DAS. Seedling growth merely reflected the GR in the main plot. Results suggest that the seedling medium composed of soil, compost, and smoked rice hull at the ratio of 5:1:1 or 3:1:1 is highly recommended for tomato and Chinese cabbage. Sugarcane is advised, if available.

Table 26. Effect of seedling medium on germination rate and plant height of tomato, summer 1985.[z]

Treatments in Seedling Stage	Germination Rate (%)		Plant Height (cm)		
	4 DAS[y]	7 DAS	11 DAS	15 DAS	21 DAS
Main Plot: Compost material					
Sugar cane	65.5 a	85.9 a	4.4 a	5.9 a	10.6 a
Mushroom	44.0 b	74.6 b	3.7 b	5.3 b	9.5 b
Rice straw	37.4 c	68.9 b	3.4 c	4.7 c	8.3 c
LSD (0.05)	2.34	9.41	0.25	0.32	0.07
Subplot: Composition ratio of soil, compost, and smoked rice hulls					
1:1:0	18.9 e	49.3 b	3.1 c	4.6 d	8.3 c
3:1:0	36.8 d	77.8 a	3.8 b	5.4 b	10.1 b
3:1:1	54.0 c	82.1 a	4.1 a	5.7 a	10.7 a
5:1:1	64.1 b	85.6 a	4.2 a	5.7 a	10.7 a
Check (soil only)	70.8 a	87.5 a	3.8 b	5.1 c	7.5 d
LSD (0.05)	6.05	10.2	0.21	0.26	0.46
Sub-Subplot: Fertilizer					
NPK 0 mg	54.7 a	77.9 a	3.9 a	5.4 a	9.3 b
NPK 100 mg/kg soil	43.2 b	75.0 a	3.7 b	5.3 a	9.7 a
LSD (0.05)	5.24	3.83	0.12	0.11	0.20

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]Days after sowing.

Table 27. Some relevant chemical properties of seedling mediums tested, summer 1985.

Treatment[z]		pH	EC	T-C (%)	T-N (%)	NH_4-N (ppm)	NO_3-N (ppm)	Total-Inorg. N (ppm)	Ava-P (ppm)	K (ppm)
Sugarcane	compost	7.57	2.95	16.467	1.846	21.6	203.0	224.6	2773.7	2487.3
1 : 1 : 0	-N	7.47	0.88	4.103	0.413	13.1	145.9	159.0	1749.2	582.5
	+N	7.25	1.09	3.604	0.356	12.6	183.0	195.6	1321.0	529.9
3 : 1 : 0	-N	7.47	0.55	1.941	0.234	9.9	81.4	91.3	1093.7	271.1
	+N	7.02	0.82	1.649	0.21	11.2	147.9	159.1	764.2	265.0
3 : 1 : 1	-N	7.42	0.41	2.079	0.199	7.9	44.9	52.8	708.2	207.5
	+N	7.03	0.86	1.525	0.198	8.9	115.9	124.8	599.5	334.7
3 : 1 : 1	-N	7.25	0.39	1.102	0.139	5.6	40.7	46.3	451.3	157.9
	+N	6.94	0.86	1.359	0.173	9.5	106.1	115.7	484.2	277.8
Mushroom	compost	7.35	4.00	9.98	0.894	6.0	489.4	495.5	2559.5	1979.6
1 : 1 : 0	-N	7.35	1.55	2.44	0.304	7.5	283.1	290.6	566.6	548.9
	+N	7.24	1.58	2.447	0.276	8.1	293.4	301.5	616	501.8
3 : 1 : 0	-N	7.41	0.93	1.518	0.182	8.5	148.7	157.3	293.2	288.9
	+N	7.20	1.20	1.414	0.175	5.4	184.2	189.6	299.8	324.3
3 : 1 : 1	-N	7.26	1.62	1.837	0.222	6.5	129.1	135.7	233.9	570.3
	+N	7.25	0.98	1.608	0.22	8.5	148.5	157.0	322.8	296.8
5 : 1 : 1	-N	7.44	0.56	1.164	0.145	5.1	74.1	79.2	158.1	163.4
	+N	7.15	1.00	1.164	0.158	10.4	146.9	157.3	237.2	260.7
Rice straw	compost	6.58	10	16.633	1.288	44.2	522.3	566.5	978.4	15189.7
1 : 1 : 0	-N	7.17	4.40	3.521	0.319	[illegible]	252.6	256.8	128.5	2386.4
	+N	7.15	4.45	4.075	0.302	[illegible]	283.5	288.8	286.6	2331.3
3 : 1 : 0	-N	7.09	2.03	1.518	0.148	6.9	96.4	103.3	26.4	830.7
	+N	7.07	2.60	1.767	0.171	5.6	175.4	181.0	88.9	1141.2
3 : 1 : 1	-N	7.15	1.75	1.539	0.159	5.1	79.5	84.6	82.4	752.7
	+N	7.09	2.18	1.559	0.179	7.8	135.4	143.1	197.7	956.1
5 : 1 : 1	-N	7.06	1.36	1.164	0.133	6.1	66.2	72.3	6.6	540.1
	+N	7.08	1.58	1.47	0.168	7.6	110.9	118.5	168.0	607.4
Check	-N	7.11	0.17	0.534	0.074	2.8	20.7	23.4	57.2	48.4
	+N	6.49	0.55	0.568	0.081	29.8	57.1	86.8	164.7	123.6

[z]-N = NPK 0 mg; +N = 100 mg NPK/kg soil.

Some relevant chemical properties of the seedlings tested are presented in Table 27. The table shows why SCC gave the highest GR and RSC, the lowest. The electroconductivity (EC) of RSC was very high (10 mmhos/cm), and retarded GR. Available potassium (Ava K) was mainly responsible for the EC increase of the medium (r^2 = 0.90). GR at 4 DAS was also greatly retarded by increased inorganic nitrogen (Inorg. N) in the medium (r^2 = 0.65).

So, multiple regression analysis was applied to the GR using EC and Inorg. N as variables; and the following equation was obtained: GR = -0.2056N - 15.74EC + 94.74 (r^2 = 0.79); where N = Inorg. N in ppm, EC in mmhos/cm and r^2 = adjusted r square. Nearly 80% of GR is governed by the two factors. If we adopt 50% GR at 4 DAS or 75% GR at 7 DAS as a critical value, EC and Inorg. N in the medium should be below 1.0 mmhos/cm (or 370 ppm Ava K) and 140 ppm, respectively.

In the first set of harvests with the rain shelter, tomato yield was slightly lower than that without it (Table 28). After the fifth harvest, however, the sheltered plants produced nearly three times as much yield as those without it. This is mainly due to serious infestation of bacterial leaf spot and late bright two months after transplanting (MAT) in the plot without shelter. Total yields of entries (except the checks) in the subtreatments were not significantly different.

Table 28. Effect of seedling medium on tomato fruit number, summer 1985.

Treatment[z]	Total Fruit No.	Frequency of (%)[y] cracking	disease	health	Ave. Fruit Wt (g)	Total Yield (g)
Main Plot: Rain Shelter						
1. NO	373 b	7.4 a	9.4 a	83.2 a	24.3 a	9061 a
2. YES	436 a	1.0 a	5.8 a	93.3 a	26.3 a	11394 a
LSD (0.05)	48.4	15.6	32.6	17.2	11.4	5487.4
Subplot: Seedling Medium						
1. SCC 3:1:1 + N (B1)	451 a	4.2 a	10.1 a	85.7 a	24.1 a	10823 ab
2. MRC 3:1:0 − N (B2)	394 ab	5.9 a	6.3 a	87.9 a	24.4 a	9638 bc
3. RSC 5:1:1 + N (B3)	432 a	4.7 a	4.3 a	91.0 a	25.7 a	11035 ab
4. RSC 3:1:1 − N (U1)	406 ab	4.5 a	5.1 a	90.4 a	26.5 a	10758 ab
5. MRC 3:1:0 + N (U2)	458 a	3.4 a	6.8 a	89.9 a	25.8 a	11835 a
6. SCC 5:1:1 + N (U3)	438 a	3.4 a	7.6 a	89.1 a	24.9 a	10835 ab
7. Check − N (Ck1)	304 c	3.2 a	10.8 a	86.1 a	26.1 a	8036 c
8. Check + N (Ck2)	353 bc	4.3 a	9.8 a	86.0 a	24.8 a	8859 c
LSD (0.05)	70.6	3.14	8.28	8.78	2.25	1762.2

[z]SCC = sugarcane compost, MRC = mushroom compost, RSC = rice straw compost. [y]Each number under cracking, disease, and healthy fruit is divided by the total fruit number.

Tomato yield linearly increased with increased EC value up to 1.2 until the 2nd harvest, and then sharply decreased. A similar trend was observed up to the 7th harvest. The medium affected the tomato yield of, at least, the first three harvests. Yield also linearly increased with increased inorganic N. This confirms the finding that the quality of the seedling medium influences tomato yield.

Chinese cabbage trial in autumn. GR was highest in the SCC and sand medium (3:1) and next in the soil, SCC, CLC, and sand combination (1:2:2:1). As in the summer tomato trial, GR in this trial was again chiefly governed by two factors, EC and inorganic N in the medium. The mediums containing soil and/or one portion of SCC gave the highest or the second highest GR. Since BASF foliar spray was conducted every 10 days during seedling preparation, seedling growth was mainly affected by oxygen diffusion into the medium and watering; therefore, porous mediums were generally superior for seedling growth.

Growth after transplanting of Chinese cabbage was not significantly different among the different mediums, except for M3 (without SCC at 1 week after treatment), but it became significant at 2 WAT. Soil-SCC mixtures gave better plant growth at 2 WAT. This indicates that nutrients, especially nitrogen in the seedling medium, play an important role in plant growth even after transplanting; hence, its concentration should not exceed a hazardous level (140 ppm N and 1.2 mmhos/cm EC for tomato).

SCC which contains lower inorganic N (225 ppm), but much higher total N (1.9%) than other composts, is recommended as medium.

The effect of the seedling medium on Chinese cabbage yield was very similar to that on plant growth at 2 WAT (Table 29). The response of yield to the different mediums was slightly different between high and low pot cultivations. So, the recommended seedling mediums are: for the high pot = M4, M6, M7, and M1; for the low pot = M1, M4, M7, and M6 in that order.

Table 29. Effect of seedling medium on Chinese cabbage yield, autumn 1985.[z]

Treatment	Germination Rate (%)[y]	Seedling Wt at 18 DAS (g)	Plant Wt at 1 WAT (g/plant)	Plant Wt at 2 WAT (g/plant)	Yield (t/ha) head	Yield (t/ha) total
Main Plot						
High pot	79.0 a	3.33 a	17.38 b	107.7 a	27.09 a	46.67 a
Low pot	80.8 a	3.83 a	20.80 a	134.9 a	30.44 a	47.70 a
LSD (0.05)	97.1	1.45	2.09	154.8	8.08	7.80
Subplot: Seedling Medium[x]						
M1 (3:1:0:1:1)	83.4 bc	3.28 c	19.95 a	129.4 abc	29.65 ab	48.63 ab
M2 (0:2:2:2:1)	42.9 d	3.35 bc	21.15 a	131.6 ab	28.50 b	46.85 b
M3 (1:0:0:2:1)	87.5 ab	2.20 d	13.30 b	94.6 d	25.40 c	42.95 c
M4 (1:2:2:1:0)	89.6 ab	3.58 b	21.68 a	141.5 a	30.63 a	51.13 a
M5 (0:2:0:1:1)	73.9 c	4.23 a	18.93 a	108.6 cd	28.45 b	45.78 b
M6 (1:1:0:2:1)	85.2 b	4.08 a	18.50 a	119.3 bc	29.25 ab	47.65 b
M7 (0:1:0:3:0)	96.9 a	4.35 a	20.13 a	124.2 abc	29.45 ab	47.33 b
LSD (0.05)	9.6	0.27	3.05	19.7	1.87	2.75

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]Surveyed 7 days after sowing (DAS). [x]Numbers in parenthesis indicate the ratio of materials used for seedling medium in volume: from the left, soil, sugarcane compost (SCC), crotalaria compost (CLC), sand, and rice hulls (RH).

Conclusion

Experiments were conducted to develop adequate seedling mediums for tomato and Chinese cabbage by using materials available locally. Recommended seedling mediums are the following:

1. Soil basis:
   a. Soil:SCC:SRH = 5:1.1 or 3:1:1
   b. Soil:SCC:Sand:RH = 3:1:1:1
2. Porous-material basis:
   a. Soil:SCC:CLC:Sand = 1:2:2:1
   b. Soil:SCC:Sand:RH = 1:1:2:1
   c. SCC:Sand = 1:3
   d. Sand:CLC = 1:2
   For c) and d), foliar spray of BASF is recommended.
3. High pot:
   a. Soil:SCC:CLC:Sand = 1:2:2:1
   b. Soil:SCC:Sand:RH = 1:1:2:1
   c. SCC:Sand = 1:3

GR was mainly governed by inorganic N and EC of the medium. Inorganic N concentration in the medium should not exceed 140 ppm and 1.0 mmhos/cm for EC. Since the seedling medium greatly affected the yield of tomato and Chinese cabbage, there is a good chance of avoiding soil-borne diseases through the use of a better seedling medium.

Advanced Cultural Practices for Summer Tomato

Introduction

High temperature and flooding are both major constraints of tomato production in the tropics. We already reported that a 50- to 100-cm raised bed with vinyl roof could improve tomato growth

and yield in both wet and dry seasons. In this study, drip irrigation, high seedling pots, and rain shelter were combined with high-bed cultivation to minimize tomato disease and to determine the right irrigation time and amount of water supply needed for high tomato yield.

Materials and Methods

In the spring trial, bed soil was heated by burning rice husk 30 cm deep in the center because of serious nematode infestation. The burned rice husk and soil were mixed to form the high bed. New soil was used for the low 30-cm raised bed placed near the original infested low bed. Both the low and high beds were covered with a transparent plastic roof to protect the tomato plants from the rain and enable the exact measurement of needed water from the drip irrigation. The soil of the old disease-infested low bed was used to test the combined effects of calcium cyanamide, submergence, chopped rice straw, and increased temperature on the following summer tomato yield. Water was supplied drop by drop in the following watering sequences:

1. 500 ml of water was successively applied every other day throughout the growth period (referred to as 'successive').

2. Specified amounts of water were applied only during the critical periods of tomato growth, and for a total of 14.5 liters/plant in four months, i.e., 4.5 liters/plant during the first week after transplanting (WAT), 3.5 liters for flowering (4 WAT), 3.5 liters for fruit enlarging (7 WAT), and 500 ml of water once a week in between the critical periods.

In the summer trial, water (750 ml/plant until the end of September, and then, 500 ml thereafter) was applied to each plant three times a week (EOD). Seedlings of heat tolerant CL 5915-153 on their high pots were placed atop the high bed which were fumigated with chloropicrin.

For nematode control, the old low bed was rototilled and mixed with chopped rice straw (10 t/ha) and nitrogen (200 kg/ha of $CaCN_2$ or $(NH_4)_2SO_4$). Then, it was flooded with water and covered with transparent plastic sheet (to increase soil temperature) which was removed one month after. The land was allowed to dry for one week, then rototilled again before a 25-cm raised bed was made. Three heat-tolerant tomato cultivars (CL 5915-93, CL 5915-153, CL 5915-223) were transplanted on 27 June 1985. Water was supplied by furrow irrigation and no rain shelter was provided.

Results and Discussion

Spring trial. The tomato yield on the high bed was only one-third that on the low bed. There are two reasons: 1) Burnt rice husk made the soil porous and greatly decreased its water-holding capacity; so, nearly one-third of the fruits had blossom-end rot due to water deficiency; 2) Drip irrigation caused and aggravated tomato diseases such as southern blight, late blight and bacterial wilt, which had been nicely controlled by the high-bed cultivation in the previous experiment.

Excess soil moisture in the vicinity of the plants favored root and stem diseases. Roots could not develop at the top soil because the layer was shallow. Neither could they expand downward owing to lack of water. So, the plants became more susceptible to diseases and nematodes, and we had to stop the high-bed experiment after four harvests.

In the new soil in the low bed, the tomato was harvested seven times. Tomato roots reached the bottom of the bed, absorbed water from the sources other than the drip irrigation, and supported better tomato growth. However, about one-fourth of the total fruits were seriously damaged by blossom-end rot; and several plants were attacked by southern blight, bacterial wilt, and mosaic virus. So, the drip irrigation system in this trial is not acceptable for tomato cultivation in the humid tropics.

Summer trial. Since drip irrigation caused serious tomato diseases and hampered tomato growth on the high bed, a high seedling pot was used in place of the ordinary PE nursery pot. Water was dropped not in the high pot, but through the pipe buried 5 cm below the pot; thus, the soil directly in contact with the plant was kept dry even immediately after irrigation.

Tomato plants actively produced fruits even after five and a half months after transplanting, with total fruit yields of 7.3 and 8.6 kg/plant in the EOD and daily water supply, respectively, after nine

Table 30. Yield and fruit number of heat tolerant tomato grown on a high bed with drip irrigation, summer 1985.[z]

Frequency of Harvest	Yield/Plant (kg)		Fruit No. per Plant	
	DW	EW	DW	EW
1st Harvest 9-20-85	0.838 a	0.608 a	31.5 a	21.5 a
2nd Harvest 9-27-85	2.089 a	1.209 b	77.2 a	46.4 a
3rd Harvest 10-3-85	2.874 a	2.036 b	106.9 a	78.5 a
4th Harvest 10-11-85	3.694 a	2.786 b	134.8 a	107.0 a
5th Harvest 10-22-85	4.854 a	4.201 a	170.6 a	145.3 a
6th Harvest 11-1-85	5.666 a	4.909 b	195.9 a	169.2 a

[z]Transplanted 9 July, 1985. Duncan's multiple range test was conducted on data at each harvest. DW = 750 ml of water applied daily in the first 3 months, and 500 ml thereafter until the final harvest; EW = 750 ml of water applied every other day

harvests. About 5 kg/plant of the fruits were harvested before November, a period which may be considered off-season (high price) for tomato (Table 30). EOD and daily watering consumed were 40 liters and 80 liters/plant of water, respectively.

Therefore, drip irrigation combined with high seedling pots is a promising technique for summer tomato cultivation. It was confirmed in this experiment that there was a great varietal difference in water requirement, that cultivars with less heat tolerance (inversely proportional to fruit size) generally required more water and were more susceptible to blossom-end rot, and that high bed cultivation dramatically saved water consumption.

Nematode control. Although we could find nematodes on the tomato roots after seven harvests, the combined treatment of $CaCN_2$, rice straw, submergence, and increased soil temperature proved to be very effective in suppressing nematode damage. The treatment supported initial vigorous growth of tomato and produced nearly 3 kg of fruits per plant in the first five harvests before November (Table 31).

Tomato cultivar CL 5915-153 was the best cultivar with regards to heat tolerance. CL 5915-223 could not set fruits during late August to early September. CL 5915-153 showed better tolerance to diseases and heat than CL 1131 line; however, its fruits were still very small. Cultivar CL 5915-93 had larger fruits, but very low fruit-setting rate at high temperature.

Table 31. Effect of nitrogen forms, chopped rice straw, submergence, and vinyl sheet cover on the yield of summer tomato cultivated in the tomato-tomato sequence.[z]

Sum of Fruit Weight/No.[y]	Yield (no. of fruits)		Yield (no. of fruits)		
	$(NH_4)_2SO_4$	$CaCN_2$	5915-93	5915-153	5915-223
Sum of Fruit Wt (g/plant)					
1st Harvest	172 a	103 b	153 a	185 a	75 a
2nd Harvest	965 a	493 a	682 a	876 a	629 a
3rd Harvest	1,668 a	1,195 b	1,244 a	1,695 a	1,355 a
4th Harvest	2,262 a	1,998 a	2,086 a	2,389 a	1,915 a
5th Harvest	2,598 a	2,551 a	2,622 a	2,861 a	2,241 a
6th Harvest	3,142 a	3,126 a	3,257 a	3,411 a	2,734 a
Sum of Fruit No. (per plant)					
1st Harvest	4.5 a	2.7 a	2.3 b	6.8 a	1.7 b
2nd Harvest	25.3 a	13.5 a	13.5 b	31.3 a	13.7 b
3rd Harvest	44.0 a	31.5 b	25.0 b	59.7 a	28.5 b
4th Harvest	57.3 a	52.5 a	41.2 b	82.8 a	40.8 b
5th Harvest	67.5 a	65.3 a	52.3 b	99.3 a	47.5 b
6th Harvest	81.2 a	82.5 a	67.2 b	118.3 a	59.8 b

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.
[y]The yield in every harvest is carried over to the next.

Conclusion

Drip irrigation combined with high seedling pot is a very promising technique for summer tomato cultivation and easily produced 5 kg of tomato fruits per plant. The combined treatment of $CaCN_2$, rice straw incorporation, submergence, and increased soil temperature proved to be very effective in suppressing root-knot-nematode damage in the tomato-Chinese cabbage-tomato crop rotation.

Evaluation of Tomato Cultivars in Relation to Cultural Practices

Introduction

To evaluate new cultivars, it is desirable to test them under different conditions because their response to different cultural practices is sometimes totally different. This project was, therefore, designed to evaluate promising tomato cultivars under different soil conditions, fertilization, and cultural practices, such as deep plowing and mulching.

Materials and Methods

In the 1984 autumn trial, cultivars used were TM 103, PT 858, PT 862, and TK 70 as a check. Three experiments on a split-split plot design with two replications were conducted at the same time. Each place had a different cropping or soil history.

The first summer trial used the split-split plot design with bed height as the treatment in the main plot, seedling pot height in the subplot, and cultivar in the sub-subplot. Three cultivars, CL 5915-93, CL 5915-153, CL 5915-223 were transplanted to the field on 4 June 1985.

The second experiment adopted the same design. The treatments were the application and nonapplication of 30 t/ha of compost (main plot), the effect of high seedling pot (subplot), and fertilization (sub-subplot). CL 5915-153 was transplanted to the field on 4 June 1985 and harvested three times.

The third experiment used the split-plot design with two replications. The treatments were cover materials for the bed (main plot) and effect of bed height on tomato yield (subplot). The tomato cultivar CL 5915-153 was transplanted on 24 June 1985 and harvested four times.

Results and Discussion

Autumn trial. In experiment 1, plastic mulch and fertilization did not affect tomato yield significantly (Table 32). Cultivar TM 103 gave the greatest fruit number, the highest yield in every harvest, but the smallest fruits. In experiment 2, deep plowing and compost application did not increase fruit number and yield significantly (Table 33). TM 103 again produced the largest fruit number, highest yield, but the smallest fruits.

In experiment 3, peat and sulphur left over from the 1984 autumn crop (Chinese cabbage) did not affect tomato yield one year after their application because soil pH gradually recovered a year later (Table 34), and tomato is more tolerant to acidity than Chinese cabbage and soybean, the affected crops a year before. Again TM 103 produced the highest fruit number and the smallest fruits. PT 858 had the largest fruits. The new cultivars, however, could not outyield TK 70 (check) under this condition.

If harvest frequency can be decreased, tomato production cost (two-thirds spent on harvesting) can be reduced considerably. For the first three harvests, TM 103 produced nearly 60 t/ha (55% of total yield); PT 858, 52 t (52%); PT 862, 54 t (54%); and TK 70, 40 t/ha (43%). Thus, the three cultivars showed various superior characters to the check cultivar: vigorous initial growth associated with early maturity (harvest), larger fruit size, high yield potential under different environments, and higher tolerance to ToMV and bacterial wilt.

The three experiments were combined and summarized in Table 35 in order to examine the effects of the previous crops on the yield of the following tomato. Tomato following rice showed vigorous

Table 32. Effects of plastic mulching and fertilization on fruit number and yield of new F1 cultivars after summer rice cultivation (experiment 1), autumn 1984.[z]

Treatment	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. Check	2156 a	80.30 a	74.90 a
2. Plastic mulching	2255 a	81.16 a	78.84 a
Subplot			
1. Fertilization 1[y]	2211 a	79.68 a	75.84 a
2. " 2[x]	2200 a	81.78 a	77.90 a
Sub-Subplot			
1. TM 103	2831 a	64.46 c	81.03 a
2. PT 858	1833 b	92.20 a	75.22 ab
3. PT 862	1954 b	85.53 b	74.35 b

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.

	N	P_2O_5	K_2O	Remark
[y]1. Basal	60	90	60	CF39
a) Top (3 WAT)	48	24	36	CF5
b) Top (6 WAT)	48	24	36	CF5
[x]2. Basal	60	80	60	straight
a) Top (3 WAT)	60	0	60	fertilizer
b) Top (6 WAT)	60	0	60	

Table 33. Effect of deep plowing and compost application on fruit numbers and yield of new F1 cultivars (experiment 2), autumn 1984.[z]

Treatment	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. Check	2498 a	78.66 a	84.07 a
2. Deep plowing	2575 a	79.64 a	87.75 a
Subplot			
1. Check	2425 b	79.11 a	81.92 a
2. Compost (30 t/ha)	2647 a	79.19 a	89.90 a
Sub-Subplot			
1. TM 103	3323 a	62.04 c	91.56 a
2. PT 858	2024 c	93.18 a	83.82 b
3. PT 862	2262 b	82.23 b	82.35 b

[z]Fertilization	N	P_2O_5	K_2O	Remark
Basal	60	60	90	CF39
Top	60	45	30	CF5
Top	60	45	30	CF3

Numbers having the same letter are not significantly different at the 5% level by DMRT.

initial growth, but fruit production steeply decreased after three harvests. The rice-CC-tomato rotation showed a similar growth pattern. Rice cultivation destroyed soil structure and Chinese cabbage (a shallow-rooted crop) improved only the upper soil-surface layer.

The soil which had not been rice cultivated for two years produced a much higher yield (110 t/ha) up to the 4th and 5th harvests with sizable numbers of fruits. Rice was very effective against nematode and soil-borne diseases, but destroyed soil physical properties, and so, decreased the yield of deep-rooted crops, like tomato.

Summer trial. In the first experiment, tomato cultivated on the 30 cm bed produced more fruits than that on the 20-cm bed (Table 36). The high pots failed to produce more fruits than the ordinary PE nursery pots (low pot). This was mainly due to lodging of tomato plants before the first harvest. Tomato on the high pot grew very vigorously in the first two months and produced many fruits, so it easily lodged whenever the bed soil got wet for a couple of days by successive rain. Also, bacterial leaf spot spread quickly from leaves dipped in furrow water at lodging; so, no fruits were produced after the second harvest.

Table 34. Effect of peat and sulphur powder on fruit number and yield of new F1 tomato cultivars (experiment 3), autumn 1984.[z]

Treatments	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. Check	3488 a	82.52 a	107.66 a
2. Peat[y]	3170 a	79.52 ab	93.98 a
3. Sulphur	3390 a	77.84 b	98.55 a
Subplot			
1. TM 103	4115 a	66.78 d	104.96 a
2. PT 858	2772 c	94.18 a	99.62 a
3. PT 862	3069 c	85.32 b	99.55 a
4. TK 70	3442 b	73.56 c	96.11 a

[z]Fertilization:

	N	P_2O_5	K_2O	Remarks
Basal	100	80	100	2 wk prior to transpl.
Top	60	0	40	3 WAT
Top	40	0	40	6 WAT

Numbers having the same letter are not significantly different at the 5% level by DMRT.
[y]Peat and sulphur powder were applied in autumn 1983. Since then, two crops (Chinese cabbage and soybean) were cultivated. During the summer 1984, the land was covered fully with soybean stalk and the latter was plowed into the soil before the autumn tomato cultivation.

Table 35. Effect of land use and previous crops on fruit number of new F1 tomato cultivars, autumn 1984.[z]

Treatments	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. After rice cultivation	2226 b	81.83 a	78.84 b
2. After C. cabbage cultivation	2336 b	78.69 a	78.51 b
3. Soil amendment	3521 a	85.12 a	111.55 a
Subplot			
1. TM 103	3496 a	66.90 c	98.02 a
2. PT 858	2187 c	93.41 a	85.29 b
3. PT 862	2400 b	85.33 b	85.59 b

[z]Summary of three field experiments (Tables 28, 29, and 30). Numbers having the same letter are not significantly different at the 5% level by DMRT.

Table 36. Effect of bed and pot heights on summer tomato yield, summer 1985.[z]

Treatment	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. 20 cm bed	2358 b	43.3 a	44.13 a
2. 30 cm bed	2648 a	44.8 a	49.88 a
LSD (0.05)	251.6	25.1	35.5
Subplot			
1. High pot	2497 a	44.7 a	48.74 a
2. PE pot	2509 a	42.4 a	45.26 a
LSD (0.05)	353.1	3.89	4.29
Sub-Subplot[y]			
1. V1	1802 c	51.7 a	41.90 c
2. V2	3258 a	31.4 c	47.63 b
3. V3	2449 b	47.6 b	51.48 a
LSD (0.05)	338.2	2.89	3.54

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.
[y]V1 = CL 5915-93, V2 = CL 5915-153, V3 = CL 5915-223.

All the cultivars yielded much higher than CL 1131. Cultivar CL 5915-153 showed the greatest fruit number, good heat tolerance and resistance to lodging, but had small fruits. CL 5915-223 and CL 5915-93 were not suitable for summer cultivation because of its low fruit-set and vigorous vegetative growth. However, they produced big fruits.

In the second experiment, compost, fertilizer, and high pots could not increase the yield of CL 5915-153 (Table 37). High pot cultivation, however, is promising if a good seedling medium is provided and staking is used against lodging.

In the third experiment, the rice straw and plastic mulches resulted in more fruits than the vinyl-sheet rain shelter which greatly decreased fruit cracking (Table 38). Bed height did not affect fruit number, but fruit cracking decreased with the increase in bed height. The 40-cm raised bed is, thus, high enough for summer tomato cultivation. CL 5915-153 has a great yield potential if good crop management is followed.

The evaluations of promising tomato cultivars used in these experiments are summarized in Table 39.

Table 37. Effect of compost application and pot height on the yield of new heat-tolerant tomato, summer 1985.[z]

Treatment	Total Fruit No.	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot			
1. Compost 0 (t/ha)	3606 a	29.6 a	47.22 a
2. Compost 30 (t/ha)	3597 a	29.3 a	46.86 a
LSD (0.05)	1797.1	8.27	11.0
Subplot			
1. High pot	3559 a	29.6 a	46.97 a
2. PE pot	3644 a	29.3 a	47.11 a
LSD (0.05)	417.2	2.50	1.44
Sub-Subplot[y]			
1. F1	3624 a	28.8 a	46.30 a
2. F2	3675 a	29.7 a	48.26 a
3. F3	3505 a	30.0 a	46.57 a
LSD (0.05)	247.6	1.89	3.94

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.

[y]Fertilization: N - P_2O_5 - K_2O

F1 basal 60 - 60 - 60	F2 basal 90 - 125 - 90	F3 basal 60 - 80 - 60
top1 60 - 60 - 60	top1 48 - 24 - 36	top1 60 - 0 - 60
top2 60 - 60 - 60	top2 48 - 24 - 36	top2 60 - 0 - 60

Table 38. Effect of covering materials and bed height on the yield of new heat-tolerant tomato cultivars, summer 1985.[z]

Treatment	Total Fruit No.	Frequency of Fruit Cracking (%)	Ave. Fruit Wt (g)	Total Yield (t/ha)
Main Plot				
1. Roof	458 b	8.3 b	34.7 a	40.67 b
2. Plastic mulch	765 a	17.2 a	33.1 a	65.09 a
3. Rice straw mulch	792 a	14.4 a	31.8 a	64.51 a
LSD (.05)	153.7	6.03	6.63	22.4
Subplot				
1. 100 cm bed	691 a	11.0 a	32.4 a	56.83 a
2. 70 cm bed	655 a	12.7 a	33.0 a	54.77 a
3. 40 cm bed	668 a	16.2 a	34.3 a	58.68 a
LSD (.05)	105.7	5.23	2.13	9.95

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.

Table 39. Evaluation of new tomato cultivation, autumn 1984 and summer 1985.

Cultivar	Yield	Fruit No.	Fruit Size	Plant Ht.	Remarks
TM 103	very high	numerous	small	medium	Vigorous growth, tolerance to TMV, highly recommended for autumn planting.
PT 858	high	few	bigger	tall	Same as above higher water requirement than CL 5915 line.
PT 862	high	medium	big	tall	Same as above.
CL 5915-93	high	medium	medium	tall	Suitable for late summer to early autumn planting, satisfying fruit size for summer tomato, insufficient tolerance to cracking.
CL 5915-153	very high	numerous	small	low	Highly recommended for summer planting, small fruit size, no tolerance to bacterial leaf spot, insufficient tolerance to cracking.
CL 5915-223	high	medium	medium	tall	Suitable for late summer to early autumn planting, satisfying fruit size for summer tomato, insufficient tolerance to cracking, no tolerance to bacterial leaf spot.

Conclusion

The high seedling pot is a promising technique for summer tomato cultivation if a good seedling medium and staking are provided on a 40-cm raised bed. Rice in a cropping sequence is effective against nematodes and soil-borne diseases, but upsets soil physical properties, resulting in a great decrease in yield. TM 103, PT 858, and PT 862 are appropriate for autumn planting; CL 5915-93, and CL 5915-223 are suitable for late summer to early autumn; and CL 5915-153 is highly recommended for summer cropping.

Rational Nitrogen Fertilization for Soybean

Introduction

It was reported that 35 ppm N gave the maximum economic yield for soybean, and that the contribution of symbiotic nitrogen fixation exceeded 50% at this concentration. This project, therefore, investigated the response of soybean to nitrogen fertilizer more precisely and to determine a rational nitrogen fertilization for high economic yield.

Materials and Methods

A pot experiment was conducted in the greenhouse in spring 1985. Soybean isolines, T 201 (nonnodulating) and T 202 (nodulating) were sown on 25 March 1985 and harvested on 15 July 1985. Plant samples were taken at flowering, pod-filling, and harvest. Nitrogen treatments are summarized in Fig. 1.

Results and Discussion

The effect of nitrogen applied at different growth stages on selected growth parameters and yield components of soybean are summarized in Tables 40 to 42. Although there were no significant differences in total soybean dry weight among the nitrogen treatments at flowering, such important growth parameters as branch numbers, pod numbers, leaf and stem weights were significantly high in the treatment which received nitrogen as the basal fertilizer.

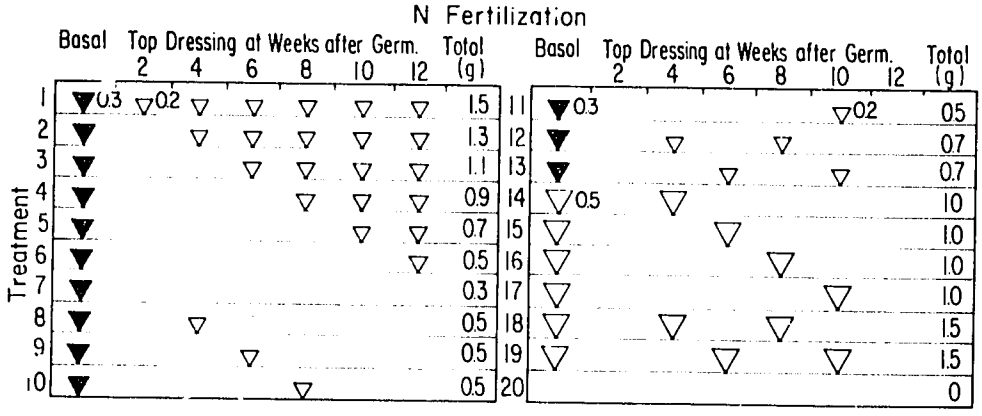

Fig. 1. Nitrogen fertilization of soybean isolines T 201 and T 202.

Table 40. Selected growth parameters of soybean at the flowering stage, spring 1985.[z]

Treatment	Plant Ht. (cm)	Branch No.	Node No.	Leaf Dry Wt	Stem Dry Wt	Root Dry Wt	Total Dry Wt
Main Plot: Cultivar							
a. T 201	23.85 a	1.50 a	7.00 a	1.90 a	1.23 a	1.11 a	4.23 a
b. T 202	25.29 a	2.06 a	7.63 a	2.03 a	1.26 a	1.03 a	4.32 a
LSD (0.05)	8.1	2.38	1.59	0.24	0.32	0.24	0.79
Sub-plot: N level							
1	26.40 a	2.13 a	7.38 ab	2.34 a	1.38 a	0.93 a	4.69 a
2	24.78 b	1.88 ab	7.13 b	1.93 b	1.28 ab	1.13 a	4.33 ab
14	24.40 b	2.38 a	7.75 a	2.06 b	1.24 ab	1.04 a	4.34 ab
20	22.70 c	0.75 b	7.00 b	1 54 c	1.09 b	1.13 a	3.75 b
LSD (0.05)	1.35	1.32	0.56	0.22	0.19	0.30	0.66

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.

At the pod-filling stage, pod number decreased with the delay in nitrogen top-dressing and with low basal application (0.3 g). No effect was seen when both basal and top-dressing were high (0.5 g). Pod number increased greatly with nitrogen application at four weeks after germination (WAG) or 6 WAG at pod-filling stage. Soybean which received nitrogen top-dressing at either 4 WAG or 6 WAG produced more pods.

Top-dressing at 8 WAG or after did not have any effect on seed number. Thus, it is very important to apply nitrogen at 4 to 6 WAG to secure enough pod number, hence, seed number.

Plants with nitrogen at 4 and 8 WAG had much heavier 100-seed weight than those without it. Seed weight seemed to increase with nitrogen application at 6 WAG until 8 WAG. So, top-dressing at 8 WAG is a key technique to greatly increase 100-seed weight. This confirms the finding that plants with high pod number but low 100-seed weight have heavier total seed weight than those with low pod number but high 100-seed weight. These findings strongly suggest that nitrogen application at 4 WAG obtains good pod yield and at 8 WAG secures high 100-seed weight.

At harvest, more than 75% of N taken up was transferred to seeds from the leaves (Table 43). The plants applied with nitrogen at a later growth stage contained more nitrogen in the leaf or stem and were not transferred to the seeds.

Table 44 shows the contribution ratio of symbiotic N fixation to total N uptake. N-fixation rate is very low in treatments 14, 15, and 18 at the pod-filling stage because of high nitrogen basal and top-dressing rates at the flowering stage. However, N fixation recovered up to 50% in treatments 14 and 15 at harvest but could not recover and was as low as 25% in treatment 18 (0.5 g basal N and 0.5 g nitrogen each at 4 and 8 WAG) keeping soil N concentration high throughout the critical period.

Table 41. Selected growth parameters of soybean at pod-filling stage, spring 1985.

Treatment	Nodule No.	Pod No.		Pod Wt		Nodule Wt	Total Wt	
	T 202	T 201	T 202	T 201	T 202	T 202	T 201	T 202
1	204	38.3	45.5	12.35	14.08	1.60	33.01	34.15
2	144	31.8	42.3	9.38	12.10	1.28	26.28	27.65
3	120	27.3	32.8	5.65	9.05	1.08	20.38	20.95
4	115	19.0	29.0	5.20	8.55	1.95	15.33	20.24
8	104	26.0	39.5	7.60	11.38	1.60	21.63	28.68
9	147	24.3	37.3	7.10	11.00	1.45	19.71	23.99
14	150	39.8	46.8	10.63	13.68	1.43	29.21	36.84
15	98	45.3	46.3	11.20	11.73	0.60	28.38	26.23
20	148	4.5	17.0	1.00	6.80	0.83	5.20	12.80

Table 42. Yield components of soybean isolines as affected by N fertilization, spring 1985.[z]

Treatment	Total Dry Wt	Pod No.	100-Seed Wt (g)	Seed No.	Total Seed Wt (g/plant)
Main plot: Cultivar					
T 201	19.99 b	27.88 b	11.15 b	55.94 b	6.54 b
T 202	28.76 a	36.70 a	16.30 a	80.70 a	13.22 a
Subplot: N Fertilization					
1	34.09 a	41.50 bc	15.05 bc	91.13 a	13.84 a
2	29.80 bc	38.38 c	17.59 a	74.75 b	13.24 ab
3	22.80 efg	28.63 e-h	14.90 bcd	61.63 c-f	9.29 cde
4	20.52 fgh	25.88 gh	14.16 cde	55.50 f	8.19 def
5	18.58 h	26.75 fgh	12.04 efg	54.38 f	6.97 ef
6	18.54 h	26.00 gh	11.97 efg	53.88 f	6.78 f
7	19.07 gh	26.00 gh	12.04 efg	56.25 ef	7.35 ef
8	23.20 ef	30.63 def	12.53 c-g	70.00 bc	9.09 c-f
9	23.30 ef	30.63 def	13.96 cde	66.50 bcd	9.80 cd
10	21.22 fgh	25.38 h	14.82 bcd	53.63 f	8.53 def
11	20.95 fgh	28.25 e-h	12.36 d-g	58.38 def	8.04 def
12	25.89 de	32.25 de	14.52 cde	72.38 b	10.98 bc
13	22.73 efg	31.00 de	13.30 c-f	65.88 b-e	9.17 c-f
14	33.12 ab	44.75 ab	14.05 cde	96.88 a	13.90 a
15	31.27 abc	46.63 a	13.69 c-f	95.63 a	13.38 a
16	28.99 cd	33.88 d	17.10 ab	70.75 bc	12.30 ab
17	21.07 fgh	29.75 efg	11.20 fg	59.13 def	6.77 f
18	34.13 a	43.13 ab	14.94 bcd	95.13 a	14.19 a
19	29.74 bc	45.88 a	13.69 c-f	89.50 a	12.48 ab
20	8.59 i	10.50 i	10.63 g	25.13 g	3.24 g

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.

The inhibition of N fixation resulting from high N concentration at the early growth stage was easily recovered by applying nitrogen top-dressing at a late stage. Top-dressing at 8 WAG still affected nodulation.

Treatments 1 and 2 gave relatively high N fixation rate and high seed weight, but were more laborious. So, the relatively high N rate at basal and top-dressing applications at 4 or 6 WAG or a low basal application and two top-dressings at 4 and 8 WAG is highly recommended to increase soybean yield greatly.

Conclusion

Nitrogen top-dressing at 4 and 8 WAG greatly increased pod number and 100-seed weight, respectively. For high yield, however, it is more important to obtain more pods than to get heavy seeds.

Table 43. Nitrogen distribution in each plant tissue at harvest stage, spring 1985.[z]

Treatment	Nitrogen Distribution (% of Total Uptake)				
	leaf	stem	root	hull	seed
Main Plot: Cultivar					
T 201	12.2 a	6.8 a	2.9 a	5.2 a	72.9 b
T 202	7.4 a	3.1 b	2.0 a	3.3 b	84.2 a
LSD (0.05)	6.3	1.9	0.9	0.7	9.8
Sub-Plot: N Fertilization					
1	7.9 de	4.1 ef	1.7 d-g	3.8 bc	82.5 ab
2	7.4 e	4.3 d-f	2.2 d-g	3.6 bc	82.4 ab
3	8.7 de	4.5 d-f	2.7 b-e	4.0 a-c	80.2 a-d
4	9.8 c-e	6.5 bc	3.9 b	3.9 bc	76.0 de
5	10.3 c-e	5.3 c-e	2.8 b-d	4.7 ab	76.8 c-e
6	9.8 c-e	6.0 b-d	2.4 c-g	5.2 a	76.6 c-e
7	11.0 b-d	5.4 c-e	2.6 b-e	5.3 a	76.0 de
8	10.2 c-e	4.2 ef	2.1 c-g	4.9 ab	78.6 a-d
9	9.3 de	4.0 ef	2.1 c-g	4.2 a-c	80.4 a-d
10	10.3 c-e	4.6 d-f	3.4 bc	4.0 a-c	77.8 b-e
11	12.6 a-c	6.4 bc	2.7 b-e	4.5 a-c	73.9 ef
12	7.6 e	4.7 d-f	2.5 b-f	3.6 bc	81.6 ab
13	8.3 de	4.7 d-f	2.4 c-g	4.5 a-c	80.1 a-d
14	9.2 de	3.7 ef	1.3 e-g	3.7 bc	82.1 ab
15	9.8 c-e	3.1 f	1.0 g	4.8 ab	81.3 a-c
16	8.3 de	3.7 ef	2.4 c-g	3.2 c	82.3 ab
17	14.0 ab	8.7 a	2.3 c-g	4.7 ab	70.3 fg
18	8.7 de	3.1 f	1.5 d-g	3.7 bc	83.1 a
19	8.8 de	4.6 d-f	1.0 fg	4.7 ab	80.9 a-c
20	14.2 a	7.3 ab	5.3 a	3.9 bc	69.2 g
LSD (0.05)	2.8	1.4	1.2	1.1	4.1

[z]Numbers having the same letter are not significantly different at the 5 % level by DMRT.

Table 44. Contribution of symbiotic nitrogen fixation to the total nitrogen uptake of soybean at pod-filling and harvest stages.

Treatment	Pod-Filling Stage	Harvest	Treatment	Pod-Filling Stage	Harvest
1	42%	45%	11	–	78%
2	50%	41%	12	–	67%
3	51%	43%	13	–	72%
4	64%	60%	14	27%	49%
5	–	69%	15	33%	55%
6	–	70%	16	–	51%
7	–	78%	17	–	48%
8	57%	60%	18	–	25%
9	64%	70%	19	–	52%
10	–	73%	20	82%	87%

N fixation was suppressed at the pod-filling stage by high nitrogen rates at 4 to 8 WAG. This was easily remedied by avoiding top-dressing at 8 WAG. A relatively high basal N rate and top-dressing applications at 4 WAG or 6 WAG, or a slightly high basal application with low N top-dressing at 4 and 8 WAG is strongly recommended to obtain a high economic soybean yield.

Continuous Cropping of Soybean

Introduction

Under intensive farming, an adequate crop rotation should be adopted to avoid continuous cropping hazards. It was reported that soybean yield decreased greatly after three successive cultivations on the same land in the temperate regions. This project is aimed to evaluate the effect of different cultural

practices on soybean yield and to determine how long soybean can be cultivated continuously on the same land in the tropics without a great decrease in yield.

Materials and Methods

Soybean was cultivated twice a year, in the spring and autumn, on the same land since the autumn of 1983. In the summer, all the experimental plots were covered with rice straw to save labor for weeding and protect the soil from the rain. Just before the autumn cultivation, the rice straw was plowed into the soil of the experimental plots. At harvest, only the pods were put away; the rest of the plants were plowed into the soil.

Results and Discussion

In the first cultivation, rice straw mulch increased soybean yield significantly, but in the second cultivation, no difference in yield was found between soybean with and without rice straw mulch (Tables 45 and 46). Deep plowing by a disc plow did not influence yield in the first three cultivations, but it caused the retardation of initial growth because the less fertile subsoil was mixed with the fertilized surface soil, resulting in low nutrient concentrations in the soil.

Compost application did not increase yield greatly with continuous soybean cultivation. Neither did the different fertilizer rates, except in the first cultivation. However, cultivar AGS 129 or Kaohsiung No. 8 (KS 8) had quite a high yield in the spring (more than 4 t/ha) and autumn cultivations (Table 47). Unlike mungbean, soybean yield was not affected by continuous cropping for four successive cultivations. The results also suggest that spring soybean is a suitable cropping system for long-term soybean cultivation. Mulched rice straw and plant residues provided a sufficient amount of organic matter in the soil.

Deep plowing by a disc plow or compost application had no significant effect on soybean yield; therefore, deep plowing should be done with a subsoiler instead and should be combined with deep placement of nitrogen fertilizer.

Conclusion

Although deep plowing, rice straw mulching, and even initial fertilization did not increase soybean yield significantly, yield gradually increased over two years and finally reached more than 4 t/ha with continuous soybean cropping.

Spring soybean followed by summer fallow with a rice straw mulch and by autumn soybean was an adequate crop rotation that sustained a relatively high yield and minimized cropping hazards.

Table 45. Effect of deep plowing, rice straw mulching, and N fertilization on soybean yield in the continuous cropping system, spring 1984.[z]

Treatment			100-Seed Wt (g)	Yield (t/ha)
Main Plot:				
Deep plowing			29.00 a	3.59 a
None			21.56 b	3.79 a
Subplot:				
Rice straw mulch (10 t/ha)			25.12 a	3.70 a
None			25.44 a	3.69 a
Sub-subplot				
	basal/top[y]	N-P_2O_5-K_2O		
F1	B	40-60-80	25.20 a	3.73 a
F2	B	20-30-20	25.53 a	3.66 a
	T	20-10-15		
F3	B	20-10-40	25.37 a	3.74 a
	T	20-30-20		
F4	B	40-60-40	25.13 a	3.72 a
F5	B	20-60-60	25.17 a	3.61 a
	T	20- 0-20		

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.
[y]10 days after flower initiation.

Table 46. Effect of deep plowing, compost application, and N fertilization on soybean yield in the continuous cropping system, autumn 1984.[z]

Treatment			100-Seed Wt (g)	Yield (t/ha)
Main Plot				
Deep plowing			15.50 b	2.74 a
None			15.79 a	2.92 a
LSD (0.05)			0.28	1.16
Subplot				
Compost (20 t/ha)			15.74 a	3.09 a
None			15.56 b	2.92 a
LSD (0.05)			0.04	0.43
Sub-Subplot				
	basal/top[y]	N-P_2O_5-K_2O		
F1	B	40-60-80	15.71 a	3.01 a
F2	B	20-30-20	15.60 a	2.96 a
	T	20-10-15		
F3	B	20-10-40	15.62 a	3.02 a
	T	20-30-20		
F4	B	40-60-40	15.64 a	2.96 a
F5	B	20-60-60	15.67 a	3.08 a
	T	20-0-20		
LSD (0.05)			0.27	0.11

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT.
[y]10 days after flower initiation

Table 47. Effect of compost application and N fertilization on soybean yield in the continuous cropping system, spring 1985.[z]

Treatment			100-Seed Wt (g)	Yield (t/ha)
Main Plot				
AGS-129			19.04 b	4.22 a
KS-8			29.32 a	3.79 a
LSD (0.05)			4.07	0.04
Subplot				
Compost (30 t/ha)			24.58 a	4.02 a
None			23.83 a	3.99 a
LSD (0.05)			1.79	0.40
Sub-Subplot				
	basal/top	N-P_2O_5-K_2O		
F1	B	0-60-80	24.15 a	3.94 a
F2	B	40-60-80	24.21 a	4.00 a
	T	30-0-0[y]		
F3	B	40-60-80	24.23 a	4.06 a
	T	30-0-0[y]		
	T	30-0-0[x]		
F4	B	70-60-80[w]	24.44 a	3.99 a
F5	B	70-60-80[w]	23.85 a	4.04 a
	T	30-0-0		
LSD (0.05)			0.75	0.13

[z]Numbers having the same letter are not significantly different at the 5% level by DMRT. [y]30 days after germination. [x]45 days after germination. [w]Deep placement of fertilization.

Bilateral Programs

AVRDC-Indonesia Bilateral Project (Preliminary Results)

Evaluation of AVRDC Sweet Potato Cultivars

Introduction

Since 1978 CRIFC has received about 3000 lines in the form of seed, tuber, or plantlets. One of the weaknesses of the AVRDC clones is their susceptibility to scab (*Elsinoe* sp.). Therefore, no line has so far been released. The AVRDC clones are usually suitable for high elevations and generally produce good plant type and good tuber form with high carbohydrate content.

Since 1984 crossing has been done between AVRDC lines and Indonesian clones Daya, Prambanan, Borobudur, and Tumpuk to breed cultivars with resistance to scab. The hybrid seeds were evaluated and screened further in Indonesia.

Materials and Methods

Two kinds of sweet potato materials, rootlets and plantlets, were received from AVRDC. The varieties planted from rootlets were 1.423, CN 1108-13, CN 1028-15, AIS 0122-2, and CN 1038-16. The *in vitro* materials were CN 1280-3, CN 1232-9, I 424.

Results and Discussion

Three varieties, CN 1108-13, CN 1038-16, and CN 1028-15, gave an average of 700 g of roots/plant, but 1.423 gave only 375 g. Two varieties, 1.423 and CN 1028-15, were medium sweet, while CN 1083-16 and CN 1108-13 were not. The cuttings have been sent to Bogor Research Institute for Food Crops and the Sugarcane Research Institute (BP3G) at Pasuruan, East Java for further research. Some *in vitro* materials (plantlets) were contaminated, so they had to be renewed before planting. Now, they are growing in the field, but are not producing root yet.

Evaluation of AVRDC Tomato Cultivars

Introduction

Bacterial wilt and late blight (*Phytophthora infestans*) are two main constraints in tomato production. In the last few years the processing tomato has been in demand for the developing tomato industry. AVRDC provided us with some cultivars which were tested for their performance in the lowland and in the highland.

Materials and Methods

Twenty varieties were planted and compared to local cultivar Intan. The design was randomized block with three replicates.

Results and Discussion

The results showed that lines PT 858 (877 g/plant), PT 862 (1099 g/plant), and Tainan Selection No. 2 (968 g/plant) had good processing characteristics and gave higher yields than 'Intan' (586 g/plant). All lines were susceptible to *Phytophthora infestans*, but not to bacterial wilt.

Evaluation of AVRDC Sweet Pepper Cultivars

Introduction

Research was done on one sweet pepper variety called 'Gypsy' (Acc. No. 2) from AVRDC.

Materials and Methods

'Gypsy' was sown and grown in plastic pots in the screenhouse.

Results and Discussion

Seed germination was 66% (33 seeds out of 50), and 23 seedlings were grown in plastic pots in the screenhouse. The fruit was elongated with an average length of 12.8 cm and an average width of 3.6 cm. The color was yellow which turned red when the pepper was fully ripe. The average yield was 62.9 g/plant.

Evaluation of AVRDC Chinese Cabbage Varieties

Introduction

Chinese cabbage is commonly cultivated in the highland. It does not ordinarily produce heads in the lowland. AVRDC accessions are grown for lowland cultivation. Trials were, therefore, conducted at Subang (100 m above sea level) to evaluate the performance of AVRDC accessions as compared with the commonly cultivated highland cultivars.

Materials and Methods

Twelve varieties were planted and compared to the local cultivar. The design was randomized block with three replicates.

Results and Discussion

The results showed that the cultivation age of transplants was an important factor to consider. The following accessions were promising:

1. No. 80-32 (heading percentage (HP), 44.6%; net crop weight (NCW), 287.5 g)
2. No. 80-37 (HP, 22.6; NCW, 146 g)
3. Hybrid 62 (HP, 21.4; NCW, 387.5 g)

Other accessions that indicated potential heading ability if older transplants were used were, as follows:

1. No. 82-46 (HP, 77.8; NCW, 0.39 kg)
2. Hybrid 58 (HP, 75%; NCW, 0.29 kg)
3. No.80-13 (HP, 66.7%; NCW, 0.29 kg)
4. No. 80-6 (HP, 60%; NCW, 0.29 kg)

Conclusion

Three AVRDC cultivars were promising. Lembang Horticultural Research Institute proposed to get $50,000 to cover operational cost for its research.

AVRDC-Korea Bilateral Program

Breeding for Heat Tolerance in Chinese Cabbage

Introduction

In Korea, no promising hybrid for lowland cultivation in summer has been found in successive trials since cvs. Sambok and Manha were released in 1981. Breeding was done to combine the desirable characteristics of AVRDC lines (heat tolerance, small heads, overlapping top leaves, and crispiness) with cultivars resistant to summer diseases from the Horticultural Experiment Station (HES). Some crosses grew well and showed an attractive heading form, but they were severely infected with soil-borne diseases after a heavy and long rainfall at the late growing stage.

Materials and Methods

Five AVRDC breeding lines in 1985 and one HES inbred resistant to diseases were added to the three advanced AVRDC lines and one HES inbred selected from previous trials. Consequently, 16 combinations top crossed between two HES lines and eight AVRDC ones were tested in summer 1985.

Results and Discussion

In general, results in 1985 were better than those of previous trials. Most of the combinations showed more than 70% ratio of harvested plants; several had around 90% (Table 1). Such good performance probably resulted from the little rainfall during the late growing period of the Chinese cabbage plants.

Analysis showed that the new HES line, coded 450, demonstrated a better combining ability than inbred 266 in most characters of the crosses with AVRDC lines. Also, the new AVRDC lines introduced in 1985 showed better hybrid vigor than the advanced ones. Accordingly, two combinations, entry no. 8 and 11, crossed with line 450 and two new AVRDC heat-tolerant lines were selected for further evaluation.

The leaves of entry no. 8 joined to form heads, and entry No. 11 produced the highest yields, although the former had a low harvest plant ratio and the latter a firm, overlapping heading form. Another combination, entry no. 3 crossed with line 450 and an old AVRDC line, was also selected. The plants headed with overlapping top leaves but did not have much good harvest ratio. The AVRDC line used as a parent of this combination segregated in the heading form (Table 2).

Conclusion

The 1985 results were generally better than the former trials. Most of plants showed the characteristics desired from the parents. All the selected crosses will be tested again in 1986.

Table 1. Performance of the combination between HES inbreds and advanced AVRDC Chinese cabbage under lowland summer conditions, June 30-August 29, 1985.

Entry	Combination	Heading Pattern[z]	Plant Wt. (kg)	Leaf No.	Head Wt. (kg)	Harvested Plants (%)	Yield (k/ha)
4	266 x -10-4-6-4[y]	SOL	2.26	35.6	1.43	66.7	27.3
5	x - 9-3-6-2	SOL	2.15	40.1	1.50	80.0	34.4
6	s - 8-4-8-3	SOL	1.63	35.4	1.13	58.4	17.4
Mean			2.01	37.0	1.35	68.4	26.4
1	450 x -10-4-6-4	SOL	2.32	41.5	1.59	71.7	32.2
2	x - 9-3-6-2	SOL	2.16	42.7	1.47	75.0	32.5
3	x - 8-4-8-3	SOL	2.07	46.5	1.54	74.2	32.7
Mean			2.18	43.6	1.53	73.6	32.5
12	266 x E-7	SOL	2.39	38.2	1.51	75.0	27.5
13	x 77M(3)-35-18-LT1	SOL	2.12	39.4	1.26	80.0	28.7
14	x 77M(3)-38-62-ST1	SOL	2.26	35.9	1.27	58.4	21.1
15	x -11-4[x]	SOL	2.19	38.5	1.49	81.7	34.6
16	x B-18	OL	2.56	42.6	1.64	90.0	42.0
Mean			2.30	38.9	1.43	77.0	30.8
7	450 x E-7	SOL	2.17	43.9	1.37	81.7	31.9
8	x 77M(3)-35-18-LT1	JU	2.26	43.9	1.55	68.3	30.2
9	x 77M(3)-38-62-ST1	SOL	2.12	42.5	1.38	80.0	31.6
10	x 11-4[x]	SOL	2.54	47.8	1.74	90.0	44.7
11	x B-18	OL	2.69	51.5	1.93	85.0	46.9
Mean			2.36	45.9	1.60	81.0	37.1

[z]SOL - semi-overlapping; OL - overlapping; JU - joined up.; [y]76M(2)-18-3-4 was omitted.; [x][CO-2/13-11 BC/13-18 BC_1] was omitted.

Table 2. Heading characteristics of Chinese cabbage inbred lines used in crosses at a summer trial.

Entry No.	Line Code	Heading Ability	Heading Form[z]	Head Size
26	450	poor	JU	-
27	266	poor	JU	-
28	76M(2) 10	medium	OL	very small
29	76M(2) 9	strong	OL:JU	very small
30	76M(2) 8	strong	OL:JU	very small
31	77M(3)-35-18-LT1	fair	OL	very small
32	[(0-2)/13-11 BC_1/13-18 BC_1]-11-4	strong	OL	very small
33	B-18	strong	OL:JU	very small
34	77M(3)-38-62-ST1	fair	OL:JU	very small

[z]JU = joined-up; OL = overlapping.

Cytoplasmic Male Sterility in Chinese Cabbage

Introduction

The similarity to the recurrent parents of CMS 60 days and Cheongbang lines in BC5F1 and BC4F1 generations, respectively, was marked 100% in 1984. However, the combining ability of the CMS (cytoplasmic male sterility) line was much lower than the recurrent parent in several crosses made in 1984. To confirm this phenomenon, further crossing trials were done.

Materials and Methods

For the *Raphanus*-originated CMS line, three inbred lines were crossed with CMS and the recurrent lines of two varieties, 60 days and Cheongbang. Then several characters related to yield were observed for the parent lines and their hybrids. For the *B. juncea* CMS, five recurrent parents were crossed with their identical CMS lines in the BC1F1 generation.

Results and Discussion

For the *Raphanus* CMS, two CMS lines bore less seeds per pollination than their recurrent ones in every cross with five combiners (Table 3). Seed germination rates of CMS lines were also lower than those of their recurrent ones, even though those of their hybrids were not much different than those of hybrids of their recurrent inbreds.

The number of leaves and the length of the largest leaf of the CMS lines and their hybrids were less than those of the recurrent ones and their hybrids at the 14th day after seeding (Table 4). This inferiority of CMS accessions was not recovered after transplanting to the field. Plant weight and number of leaves of the CMS lines and their hybrids were still less than those of the recurrent ones and their hybrids at the harvest stage (Table 5).

The results, in short, suggested that the CMS line in the BC6F1 or BC5F1 generation was not isogenic with the recurrent parent yet, although its appearance was very similar to the recurrent one. Therefore, the combining ability of CMS lines should be studied again after making isogenic lines by some more backcrosses.

Table 3. Number of seeds per pollination and germination rate of CMS, recurrent, and combined lines of Chinese cabbage.[z]

			SC		DK		N 60 D		Unknown		Seoul	
	Parents		5.9	92.5	11.0	46.3	7.4	70.6	15.3	78.8	8.4	99.4
CMS 60 (BC6F1)	9.4	80.7	6.8	79.3	8.1	80.0	7.6	90.8	6.0	92.2	7.4	76.7
Recurrent	15.4	96.3	16.5	88.1	16.3	80.0	12.0	80.0	13.4	91.9	18.3	93.1
Ratio (%)	61.0		41.2		49.7		63.3		44.8		40.4	
CMS CB (BC5F1)	5.6	44.2	5.8	85.0	3.7	91.3	8.3	86.3	4.6	58.8	8.4	—
Recurrent	4.9	92.5	11.8	98.1	14.2	89.4	13.1	81.3	8.3	79.4	13.5	85.6
Ratio (%)	121.7		49.2		26.1		63.4		55.4		62.2	

[z]The number of buds pollinated was 39 to 271 in each mate. The first column of every Chinese cabbage line refers to number of seeds and the second column, to germination rate. CMS 60: CMS (cytoplasmic male sterility) 60 days. CMS CB: CMS Cheongbang. SC: Shimoyama Chitose; DK: Daehyeong Karack; N 60 D: Naebyeong 60 days.

Table 4. Number of Chinese cabbage leaves and length of the largest leaf of CMS, recurrent lines, and their hybrids at the 14th day after seeding.[z]

			SC		DK		N 60 D		Unknown	
	Parents		5.0	7.0	5.2	7.0	5.2	8.0	4.4	8.6
CMS 60 days	4.0	4.5	3.6	5.4	4.0	5.9	4.2	6.8	4.6	7.8
Recurrent	6.0	10.7	4.4	8.6	4.8	8.8	4.8	8.6	4.6	10.5
Ratio (%)	66.7	42.1	81.1	62.8	83.3	67.1	87.1	79.1	100.0	74.3
CMS CB	3.8	6.2	4.0	5.7	3.8	5.4	4.2	5.0	4.0	4.3
Recurrent	4.2	7.6	5.0	9.3	5.0	8.6	4.8	8.7	5.0	9.3
Ratio (%)	90.5	81.6	80.0	61.3	76.0	62.8	87.6	57.5	80.0	46.2

[z]The first column of every Chinese cabbage line refers to number of leaves and the second column, to length of the largest leaf. CMS: cytoplasmic male sterility. CB: Cheongbang. SC: Shimoyama Chitose; DK: Daehyeong Karack; N 60 D: Naebyeong 60 days.

For the *B. juncea* CMS, the average seed-setting ability was tremendously improved on the average in the 1985 breeding (Table 6). However, it was so different from the recurrent parent that the CMS line of the variety Seoul and Haeckbaechu bore only 8.5 and only 0.56 seeds per pollination, respectively (Table 7). The plants of each CMS line grown in the field still showed severe chlorosis regardless of its seed-setting ability. The backcross with the recurrent parent for breeding the isogenic CMS line will be continued.

Table 5. Plant weight and number of leaves of CMS, recurrent and combined lines of Chinese cabbage at harvest stage.[z]

			SC		DK		N 60 D		Unknown	
Parents			3.14	53.5	2.75	53.6	2.58	58.6	2.74	55.3
CMS 60 days	2.87	48.2	2.84	49.0	3.07	49.7	2.85	52.7	3.25	54.7
Recurrent	3.61	56.4	3.77	52.3	3.37	52.2	3.80	57.3	4.18	59.6
Ratio (%)	79.5	85.5	75.3	93.7	91.7	95.2	75.0	92.0	77.8	92.7
CMS CB	2.90	56.5	3.18	50.4	2.84	50.4	2.62	54.1	2.54	52.8
Recurrent	2.19	60.8	4.46	58.8	3.66	56.4	3.56	60.7	3.52	64.1
Ratio (%)	132.4	92.9	71.3	85.7	77.6	89.4	73.6	89.1	75.0	82.4

[z]The first column of every Chinese cabbage line refers to plant weight and the second column, to number of leaves. CMS = cytoplasmic male sterility. CB = Cheongbang; SC = Shimoyama Chitose; DK = Daehyeong Karack; N 60 D = Naebyeong 60 days.

Table 6. Seed yield of CMS lines of Chinese cabbage originated from *B. juncea*.

Year	No. of Recurrent Parents	No. of Pollinations (A)	No. of Seeds	B/A
1983	11	1,429	35	0.02
1984	13	1,403	401	0.29
1985	5	1,712	5,101	2.98

Table 7. Seed-bearing ability and germination rate of each recurrent parent to CMS lines of Chinese cabbage originated from *B. juncea*.

Recurrent	Flowers Pollinated (A)	Seeds (B)	B/A ave.	B/A min. - max.	Germination Rate
Naebyeong 60 days 3[z]	445	436	0.98	0.15 - 1.71	86.7
Cheongbang 3	116	359	3.10	2.57 - 3.67	95.0
Daehyeong Karack 3	153	803	5.25	1.13 - 9.21	95.0
Haeckbaechoo 3	627	348	0.56	0.31 - 1.07	-
Seoul 3	371	3,155	8.50	7.20 - 10.68	100

[z]Three times of the cross to the CMS line.

Conclusion

The results with the *Raphanus* CMS material suggested that in the BC6F1 generation, it was not isogenic with the recurrent parent yet, although its appearance was very similar to the recurrent one. The combining ability of CMS lines should be studied again after making isogenic lines by additional backcrosses. Although the average seed-setting ability of *B. juncea* CMS lines was tremendously improved, they were so different from their recurrent parents that they bore low rates of seed per pollination and each CMS line grown in the field still showed severe chlorosis regardless of its seed-setting ability. Backcrossing with the recurrent parent for breeding isogenic CMS lines will continue.

Breeding of F1 Nonstaking Tomato Hybrids for Processing

Introduction

The performance test in 1985 was concentrated on four cross combinations which had provided constantly acceptable yields and high fruit quality in two years of screening.

Materials and Methods

An F6 generation of CL 1561 which was developed by AVRDC was used as pollen parents in two cross combinations among them.

Results and Discussion

Heavy rainfall during June and July caused an unusually high percentage of fruit rot (around 50%) this year. Normally, average fruit rot percentage of the previous years was 30% at the highest.

The yields and disease resistance of the entries are shown in Table 8. Two cross combinations, 79078 x ARC and 79078 x CL 1561 (F6) gave almost the same levels of estimated yield.

Table 8. Yield and disease resistance of nonstaking tomato hybrids for processing.

Crosses or Varietal Name	No. of Total Fruit Set/Pl.	No. of Defective Fruits/Pl.	% Defective Fruits	No. of Marketable Fruits/Pl.	Estimated Yield/Ha	Index	Disease Resistance Score[/]
79078 x ARC	96.7	41.4	42.8	55.2	51.0	100.0	2.7
79078 x CL 1612	107.9	53.4	49.5	54.5	46.5	91.2	3.0
Peelette x CL 1561 (F_6)	95.5	44.4	46.5	51.1	45.0	88.2	3.3
79078 x CL 1561 (F_6)	113.4	47.6	42.0	65.9	52.5	102.9	2.7
Jinhong	91.8	38.9	42.4	52.9	51.0	100.0	1.3
Kagome 77	76.7	36.6	47.7	40.0	48.0	94.1	2.0

[/]Scores were recorded three times, early, middle, and late stages of growth in the field. Major diseases observed were virus diseases, late blight, and early blight. Scoring: 0 = no infections, 3 = fairly infected, 9 = all plants killed by some diseases.

Conclusion

Considering the unusual weather conditions this year, yields were not likely to represent the real ones. Therefore, further studies with additional entries are necessary.

Improving Two Staking Tomato Hybrids for Processing and Fresh Market

Introduction

In 1982, a nonstaking processing tomato hybrid, cv. Jinhong (Wongyo No. 401), was released to local commercial seed companies. It has not been used, however, because of the heavy rainful at harvest, its cultural practices have not been established among the Korean farmers, and importation of tomato paste is cheaper. Staking tomato can be grown by farmers without any difficulty in cultivation and can also be used for the fresh market and processing companies. Cvs. Jokpoong and Hongjo are the results of such breeding effort.

Materials and Methods

Seeds of the parental lines were distributed to the Korean Seed Association in the spring of 1985, and 53 advanced lines ranging from F3 to F4 generations were screened.

Results and Discussion

The major horticultural traits and yield of the new hybrid varieties, Jokpoong and Hongjo, are shown in Table 9.

Since cvs. Jokpoong and Hongjo still have some drawbacks in terms of fruit shape and disease resistance, new advanced lines are in the process of improvement. The 53 advanced lines were screened for yield, fruit quality, and disease resistance. Among them, 18 lines and 26 individual plants were selected. The new 44 breeding lines will be screened again and some cross combinations made in 1986.

Table 9. Major horticultural traits and yields of Jokpoong and Hongjo.

Variety	Fruit Wt. (g)	Soluble Solid (Bx.)	Pulp Yield Ratio (%)	% Defective Fruits[z]	Disease Res.[y]	Estimated Yield (t/ha)	Remarks
Jokpoong	170-180	4.3	79.7	0	Strong	54.0	
Hongjo	130-140	4.2	81.0	12.9	Good	57.1	
Mater No. 2	160-170	4.2	80.0	24.5	Strong	48.6	Japanese F_1

[z]Fruits spoiled by rot, diseases, and blossom end rot. [y]Disease resistance was investigated in the field with special reference to tomato mosaic virus, early blight, and late blight.

Conclusion

More screening is needed to improve yield, fruit quality, and disease resistance of Jokpoong and Hongjo.

Regional Adaptability Test for Processing Tomato Varieties

Introduction

Several processing tomato varieties developed by the Horticultural Experiment Station (HES) or AVRDC were tested for regional adaptability at six locations in 1985.

Materials and Methods

Ten nonstaking tomato varieties or lines and five staking cultivars were tested at Suwon and Kangwon provinces. In the mountainous district of Kangwon, three locations were chosen according to altitudes. The locations, altitudes, seeding and transplanting dates, and entries used are shown in Table 10. Only five varieties each of nonstaking and staking tomatoes were used in Kyongnam and Jeju provinces because of budgetary and personnel constraints.

Results and Discussion

Unusual weather conditions prevailed throughout the country during the year 1985, so that, the results were not reliable especially in terms of marketable yield. Except in Kangwon province, heavy rainfall just before harvest resulted in a very high percentage of fruit rot incidence never experienced before. To make things worse in Jeju, three big typhoons destroyed the late-growing tomatoes which were sown on 6 July and transplanted to the field on 16 August.

The summary of the trial is shown in Table 10. The last column of the table lists the names of three highest ranking varieties in the order of listing. No new varieties appeared among the staking

Table 10. Summary of regional adaptability test for processing tomato varieties in Korea.

Location	Altitude	Seeding Date	Transplanting Date	Entries[1]	Promising Entry
Suwon (Middle part)	Lowland	March 1	May 4	N: PT 3027, PT 1600, PT 870, TM 103, PT 858, PT 862, Peto 86, Tainan 2, Kagome 77 Jinhong (10)	N: TM 103, PT 3027, Jinhong
				S: Hongjo, Jokpoong, PT 1721, PT 1723	S: Jokpoong, Master 2, Hongjo
Kangwon (North-eastern,	400 m (Yongpyong)				N: TM 103, PT 862, Jinhong S: Hongjo, PT 1723, Master 2 Part)
	600 m (Jinbu)	April 1	May 20	Ditto	N: Jinhong, PT 1600, PT 858 S: Hongjo, Jokpoong, PT 1723
	800 m (Doam)				N: Kagome 103, Peto 86, PT 870 S: Master 2, Jokpoong, PT 1723
Kyongnam (Southern coast)	Lowland	Feb 28	April 30	N: PT 3027, Peto 86, Tainan 2 Kagome 77, Jinhong (5)	N: Kagome 77, Peto 86, Jinhong
				S: PT 1721, PT 1723, Hongjo, Jokpoong, Master 2	S: Master 2, PT 1723, PT 1721
Jeju (Southern island)	100 m (Aewol)	March 5	April 27	Ditto	N: Kagome 77, PT 3027, Jinhong S: Master 2, PT 1721, PT 1723
		July 6	August 16		N: Jinhong, PT 3027, Kagome 77 S: Hongjo, Jokpoong, PT 1723

[1]N = nonstaking; S = staking.

varieties comparable to cvs. Jokpoong, Hongjo, and Master 2. TM 103 showed relatively good performance among the nonstaking varieties in Suwon and in two locations of Kangwon province.

Conclusion

Inclement weather spoiled the harvest of tomatoes which had a high percentage of fruit rot. Consequently, the results are not reliable.

13th International Mungbean Nursery Trial

Introduction

Twenty mungbean accessions were received from AVRDC.

Materials and Methods

Twenty AVRDC mungbean accessions were planted on 4 July 1985. The spacing between rows was 60 cm with 20 plants per linear meter on the row. Fertilizers applied were 40 kg N/ha, 70 kg P/ha, and 60 kg K/ha.

Results and Discussion

The three top yielders (Table 11) were VC 3061-A (1.63 t/ha), the check VC 1973-A (1.56 t/ha), and V 3724 (1.53 t/ha). They were, however, fairly susceptible to MMV, lodging, CLS, and PM.

Table 11. Performance of 20 AVRDC accessions in the 13th International Mungbean Nursery Trial at Suweon, Korea.

Entry No.	AVRDC Acc. or Cross No.	Days to First Flower	Plant Ht (cm)	No. of Plant per m^2	Pods per Plant	1000-Seed Wt (g)	Yield (kg/ha)	Yield Index	Disease MMV	Disease PM	Disease CLS	Lodging
1	V 2010	48	94	25.7	5.5	59	894	57	2	2	4	2
2	V 2272	56	124	25.7	11.3	26	517	33	2	1	2	2
3	V 2984	44	109	30.7	7.7	35	982	63	2	3	4	2
4	V 3476	47	90	30.7	7.6	48	1,119	72	4	1	4	1
5	V 3726	41	63	29.3	10.1	59	1,529	98	2	3	2	2
6	V 6017	54	87	27.3	6.8	45	688	44	2	1	1	1
7	VC 1482-E	51	92	25.0	11.6	49	1,442	93	2	1	2	1
8	VC 1628-A	48	91	31.3	9.5	55	1,174	75	3	2	2	1
9	VC 1973-A[/]	43	84	33.0	7.7	59	1,558	100	2	1	3	1
10	VC 2523-A	47	97	28.0	10.6	44	1,244	80	2	1	3	2
11	VC 2750-A	50	95	30.0	7.4	53	1,469	94	2	1	1	1
12	VC 2754-A	50	101	32.7	7.5	59	1,369	88	2	1	1	1
13	VC 2755-A	50	107	32.7	6.0	61	1,147	74	2	1	1	1
14	VC 2764-A	49	110	32.0	8.6	53	1,273	82	3	1	1	1
15	VC 2764-B	50	102	31.3	8.9	54	1,388	89	3	1	1	1
16	VC 2768-A	49	88	26.7	8.4	57	1,362	87	4	1	1	1
17	VC 2768-B	49	103	27.3	6.7	58	1,117	72	4	1	1	1
18	VC 2771-A	50	102	30.3	8.6	58	1,384	89	4	1	1	1
19	VC 2778-A	49	111	31.0	6.3	54	1,144	73	4	1	3	1
20	VC 3061-A	45	83	28.3	6.7	53	1,629	105	3	1	3	1

[/]Check variety, Seonhwa-nodgu.

AVRDC-Malaysia Vegetable Research Program

The executive agency for the program is the Malaysian Agricultural Research and Development Institute (MARDI) at Serdang, about 20 km from Kuala Lumpur. It has 28 research stations and a multidisciplinary team of 26 vegetable research staff. Malaysia is roughly self-sufficient in fresh vegetables and even produces an appreciable surplus for export to Singapore.

The vegetable industry, however, faces a number of problems, among which are poor varieties and planting materials, pests and diseases, crop management technology, postharvest losses, soil/land problems, and water excess or shortage.

The training component is now well under way. So far, 14 MARDI staff have visited AVRDC, either as production trainees or on special purpose training program. With respect to consultancy trips, MARDI needs assistance from AVRDC on the following areas of expertise: breeding, entomology, crop management and virology.

The research component has become more and more important and is now a major part of the program. The bulk of the research work consists of vegetable trials involving either AVRDC crops or cultivars from other sources. Another small component deals with pathological work.

Soybean Trial

Introduction

Since soybean is a low priority crop in Malaysia, the trial was run only as an observational trial (nonreplicated) and involved a relatively small number of entries.

Materials and Methods

The trial included 10 advanced AVRDC lines and a local check. The lines were grown in single three-row plots at the Jalan Kebun Station. Evaluation was done by visual assessment of the plants compared with the check.

Results and Discussion

Out of the 10 lines, four (AGS 58, AGS 129, AGS 130, and AGS 154) compared favorably with the local check, CV Palmetto. The other six lines were obviously inferior to the check. The plants were either too short and low-yielding (AGS 85, G 9053), were difficult to harvest because of an intricate branching pattern (AGS 160, AGS 190, G 2261), or had very small grains (G 2120). The four selected lines will eventually be included in replicated yield trials with other promising materials by the MARDI breeder for legume crops.

Conclusion

Four lines out of 10 looked promising and will be included in a replicated yield trial.

Mungbean Trial

Introduction

Like soybean, mungbean is also a very low priority crop in Malaysia. Therefore, only a small observational (nonreplicated) trial was conducted.

Materials and Methods

Ten advanced AVRDC lines were planted in single plots and compared with the local check also from AVRDC. No obvious differences could be detected by simple visual assessment, as all the plots, including the check, looked very similar both in vegetative growth and pod yield. The trial was then evaluated by harvesting and measuring the grain yield of the central row of each plot. Though these measurements were obtained from single replicates, they were viewed with confidence as giving good approximations of the actual yields, as the plots were very uniform.

Results and Discussion

Only VC 2768-A and VC 1628-A outyielded the check (VC 1163-2-2-6-2P) and were, hence, selected for inclusion in a subsequent yield trial. The three lines yielded 1.83, 1.68, and 1.58 t/ha, respectively. The other eight lines were discarded, as they yielded less than the check. They were, by order of decreasing yields, VC 1482-E, VC 1973-A, VC 2768-B, VC 1764-A, VC 2523-A, VC 2778-A, VC 2755-A, and VC 2750-A. The overall yield was substantially reduced by severe pest damage (pod borers).

Conclusion

Only two promising AVRDC lines will be included in a future yield trial.

Tomato Evaluation Trial

Introduction

Twenty-three AVRDC tomato lines were evaluated, along with four local checks.

Materials and Methods

Two trials were conducted: one included 16 lines of determinate growth habits and the other with seven indeterminate lines (Table 1). Both trials were conducted according to a randomized complete block design with three replications. Each plot had two rows, 7.2 m long and 1.5 m wide. Each row had 12 plants spaced 60 cm apart.

The trials were evaluated by measuring the plot yields (both marketable and total) and the mean fruit size. Bacterial wilt resistance was evaluated on a 1 to 5 scale defined as follows: 1 - highly resistant, less than 5% wilted plants; 2 - resistant, between 5 and 10% wilted plants; 3 - between 10 and 25% wilted plants; 4 - between 25 and 50% plants wilted; 5 - more than 50% plants wilted.

Results and Discussion

Table 1 gives the marketable and total yields, mean fruit sizes, and bacterial wilt ratings. The analysis of variance revealed highly significant differences in yield, both marketable and total. The yields were low on the whole mainly because of severe damage by bacterial wilt and very heavy rains during the trial. Extensive defoliation of the plants by the leaf spot disease (*Cercospora fuligena*, *Corynespora cassiicola*) resulted.

Table 1. Results of the evaluation trials for determinate and indeterminate tomato lines.

Line	Marketable Yield (t/ha)	Total Yield (t/ha)	Fruit Size (g)	Bacterial Wilt Rating
Determinate Tomato				
CL 5915-93D4-1-0	11.9	19.3	50	1
CL 5915-136D4-1-0	6	8.1	26	3
CL 5915-153D4-3-3	1.3	1.8	25	4
CL 5915-153D4-3-9	0.1	0.2	40	4
CL 5915-223D4-2-1	12.5	21.8	53	1
CL 5915-223D4-2-2	16	24.4	45	1
CL 5915-229D4-1-3	0.3	0.5	47	4
CL 1131-0-0-13-0-6	9.6	13.6	27	2
CL 1131-0-0-65-15-0-0	15.3	19.3	24	1
CL 1131-4-0-43-8-1	18.7	24	27	1
CLN 65-349D5-1-0	9.1	15.9	47	1
CLN 91-392D5-1-0	0.4	1.5	34	4
CLN 91-392D5-2-0	3.3	7.2	47	3
CLN 95-77D5-2-0	0.02	0.02	37	4
CLN 95-280D5-1-0	9.8	15	55	1
CLN 95-280D5-3-0	6.9	12.9	51	1
MT 1 (Ck)	12.2	17.6	29	1
MT 11 (Ck)	14.5	21	45	1
Local Banting (Ck)	0	0		5
Local White (Ck)	0	0		5
LSD 5% = 4.7 t/ha (marketable yield); 5.2 t/ha (total yield)				
Indeterminate tomato				
CL 5915-16D4-7-4	1.3	2.7	30	3
CL 5915-39D4-1-2	5.3	10.8	40	2
CL 5915-206D4-2-5	8.7	19.9	60	1
CL 5915-553D4-3-0	6	10.2	33	1
CL 5915-553D4-6-6	5.4	9.7	36	1
CLN 95-59D5-1-0	4.6	8.4	25	2
CLN 95-244D5-1-0	4.3	6.9	34	2
MT1 (Ck)	8.4	12.4	34	1
MT11 (Ck)	7.6	13.3	51	1
Local Banting (Ck)	1.8	2.8	34	4
Local White (Ck)	0.2	0.9	41	4
LSD 5% = 3.4 t/ha (marketable yield); 6.2 t/ha (total yield)				

Based on fruit size as compared with the best check and on yield which depended largely on resistance to bacterial wilt and defoliating agents, five lines were selected from the two trials: four from the determinate group (CL 5915-93D4-1-0, CL 5915-223D4-2-1, CL 5915-223D4-2-2, and CLN 65-349D5-1-0) and one from the indeterminate lines (CL 5915-206D4-2-5). All these lines were highly resistant to bacterial wilt. The best check was MT 11. Although also yielding and highly resistant to bacterial wilt, MT 1 was handicapped by its small fruit size. Both MT 1 and MT 11 were selected from AVRDC germplasm.

The two local varieties (Local Banting and Local White) were worthless because of excessive susceptibility to bacterial wilt. They are, nevertheless, grown in the lowlands in Malaysia; but this is only possible if the soil is burned prior to planting and the land was not previously cropped to tomato.

Screening for Virus Resistance in Chilli

Introduction

Virus diseases are undoubtedly the most serious problem in chilli cultivation in Malaysia. Total crop failures due to virus damage are common. Commercially grown varieties are all susceptible.

The problem is complex because several viruses are involved. A quantitative and comprehensive survey as to the distribution and relative importance of these viruses throughout the country still remains to be done. In search of possible sources of resistance, chilli materials with reported resistance to several viruses were ordered from the Texas Agricultural Experiment Station.

Materials and Methods

Three lines were received: Tam Bel 2, Tam Mild Chile 2, and Tam Mild Jalapeno-1. They were planted in the field to assess their performance against the MARDI selections MC 4 and MC 5. Seed samples were also given to MARDI virologists for laboratory tests with artificial inoculations.

Results and Discussion

All three lines were found susceptible in both tests. In the field, they exhibited severe virus-like symptoms as the checks and showed much less adaptation to local conditions. This made them very difficult to establish in the field after transplanting. In the laboratory test, they were found susceptible to CMV and PVY. These negative results are thought to be due to the occurrence of different viruses/strains in Malaysia than in Texas.

TEV and pepper mottle are reported to be most serious in Texas, whereas they have not been reported here. It is worth mentioning that virus diseases are also severe on sweet pepper and are the main reason for the decline of sweet pepper cultivation in Cameron Highland.

Conclusion

The three lines from Texas were susceptible to viruses and not adapted to the local conditions of Malaysia.

Assessing Tomato Reaction to Black Leaf Mold

Introduction

Black leaf mold (*Cercospora fuligena*) was the most serious fungus disease in the tomato yield trial and has been repeatedly observed to cause serious damage on tomato in Malaysia. As some differences in disease severity were observed among the tomato lines included in the trial, it was decided to undertake the present study in the greenhouse with the same lines inoculated artificially to assess disease reaction more accurately and determine whether differences in resistance could be detected.

Materials and Methods

All 27 tomato lines previously evaluated for yield were tested (Table 1). An additional set of nine accessions received from USDA with reported resistance to early blight were included in the trial: PI numbers 105 267, 126 913, 128 174, 250 432, 255 829, 255 847, 263 725, 263 726, 276 423. The plants were raised in small plastic pots and inoculated at the seedling stage with an isolate from the Station.

Results and Discussion

Most of the lines were susceptible. The leaf area was extensively covered with heavily sporulating spots. Three lines were moderately resistant (few and small spots, slightly sporulating): CLN 91-392D5-2-0, CLN 91-338D5-2-0, and PI 250 432. Four lines were moderately susceptible (moderate sporulation and spot number): CL 5915-39D4-1-0, CL 5915-223D4-2-2, PI 105 267, and PI 255 829.

Conclusion

In view of the seriousness of this pathogen and the scarcity of information about its biology, it might be worthwhile to conduct further investigations, especially with respect to resistance.

Other projects have been started to search for sources of resistance to early blight of tomato and Phoma stem blight of asparagus. The latter disease has become very severe at the Jalan Kebun Station and is causing very heavy damage on the first asparagus cultivars that have already been planted in the field.

Other Vegetable Trials

The following vegetable trials are now under way: Chinese cabbage (19 AVRDC lines), hot pepper (5 cultivars), sweet potato (3 cultivars) and cauliflower (3 cultivars). The hot pepper, sweet pepper, and cauliflower included in these trials were preselected at AVRDC for adaptation to the tropical lowlands in the AVRDC New Vegetable Project. All these trials are now in the field and will be evaluated upon harvest. The Chinese cabbage trial was delayed by severe damping-off which killed seedlings. The usual medium used at the Station for raising seedlings is unsterilized peat soil, which often results in severe damping off, especially with crucifers.

A sweet potato observational trial is also under way, which includes 25 AVRDC elite selections. These selections were obtained from tissue culture and are being increased and planted in single rows to evaluate their performance under local conditions and eventually assess their reaction to sweet potato scab. The disease was found to occur naturally at the Jalan Kebun Station.

Beside these trials which all involve either the AVRDC mandate or new vegetable crops, other trials are planned which include a number of vegetable species ordered from various sources, especially international seed companies. This was initiated in agreement with MARDI, as the Malaysian vegetable program is involved with far more vegetable species than that of AVRDC. So far, a total of 333 cultivars have been received: asparagus (45 cultivars), broccoli (11), cabbage (25), carrot (19), cauliflower (29), cucumber (24), eggplant (20), garlic (5), lettuce (18), onion (14), pea (7), sweet potato (31), hot pepper (36), radish (9), spinach (17), tomato (22), and turnip (1).

These will be tested in observational trials, and the best accessions will be evaluated in replicated yield trials at a later stage. Seed samples of all cultivars were sent to the breeder of the Cameron Highland Station for testing in cool conditions. Asparagus is a new and highly valued crop in Malaysia. The cultivars were given to the MARDI breeder at Jalan Kebun and most have already been planted.

Pathology

This component mainly deals with the search for resistance to some important diseases of vegetables.

AVRDC-Philippine Outreach Program

AVRDC Philippine Outreach Program (AVRDC/POP) conducts research on mungbean, soybean, Chinese cabbage, tomato, and sweet potato, mainly to evaluate AVRDC varieties and cultural practices and determine their suitability to local conditions and requirements.

Since its establishment, the AVRDC/POP has released through the Philippine Seed Board the following varieties: Chinese cabbage: Hybrid 62 as Reyna Elena; sweet potato: LO-323 as BPI Sp-1 and CI 693-9 as BPI-Sp2; mungbean: VC 1163 as BPI Mg-2; and soybean: Ag 73 as BPI Sy-4. Four lines of the processing-type tomato have been identified and are being grown to supply the needs of the local tomato-paste industry.

Evaluation and Selection of AVRDC Mungbean Breeding Lines

Introduction

The overall objective of the mungbean breeding program is to develop varieties adapted to local agro-climatic conditions. The criteria for selection in this study were yield potential, early and uniform matarity, resistance to common pests and diseases, tolerance to lodging, and good seed qualities.

Materials and Methods

For the early breeding lines, segregating populations from 29 cross combinations were grown for two seasons to advance their filial generation and to select promising lines under different environmental conditions and disease pressure. Variety MG50-10A, susceptible to Cercospora leaf spot and powdery mildew, was planted around the subplot of each cross to provide a source of inoculum for natural field infection. The bulk-pedigree method was used in purifying and selecting segregating populations.

In the advanced group, 30 advanced breeding lines and a check, Pag-asa 3, were planted during the wet season for further field evaluation.

Results and Discussion

Bean yields ranged from 156 kg/ha for VC 2904-2B-1 to 1028.6 kg/ha for VC 2784-2B-1. The grand mean yield for the 31 entries was 487 kg/ha. The check Pag-asa 3 yielded 226 kg/ha. So far, six lines (VC 3668-2B-1, VC 3830-B-3-1, VC 3865-B-4-1, VC 3791-B-1-1, VC 1881-B-11-1, and VC 3897-B-3-1) were rated highly resistant to Cercospora leaf spot (CLS) and one entry (VC 3881-B-11-1), to virus infection.

Conclusion

Six lines were found highly resistant to CLS and one to virus infection.

Preliminary Mungbean Yield Trial

Introduction

Promising accessions/cultivars received from AVRDC are evaluated, selected, and purified under local environmental conditions. The stable ones are then field-tested in preliminary yield trials (PYT).

Materials and Methods

Three sets of trials with 10 entries for Set E, 16 entries for Set F, and 40 entries for Set G were evaluated during the dry and wet seasons of 1985. The AVRDC standard procedure for mungbean evaluation was used.

Results and Discussion

Set E. The dry season (DS) trial produced no significant differences in bean yield among the entries. Yields ranged from 904 kg/ha to 1014 kg/ha. Two test entries, VC 2720-A (1268.7 kg/ha) and VC 2778-B (1067.9 kg/ha) outyielded the highest-yielding check variety Pagasa 3 (1048.7 kg/ha).

A lower grand mean yield of 683.8 kg/ha was obtained during the wet season (WS). This was due to several typhoons and heavy rains that prevailed during the entire crop season. Only VC 2778-B with mean yield of 821.47 kg/ha produced higher, but not significantly different, yield than Pag-asa (780.67 kg/ha).

All the entries flowered within 30 to 32 days and matured 52 to 57 days after planting. VC 2778-B produced the biggest seed size in both seasons. Negligible symptoms of Cercospora leaf spot were observed during the dry season. Four AVRDC lines (VC 2720-A, VC 2778-B, VC 2307-A, and VC 2768-B) were less infected with CLS than Pag-asa 3 (check) during the wet season.

Set F. The grand mean yields of the 16 entries were 1.16 t/ha for the dry season and 0.65 t/ha for the wet. Yields during the dry season varied from 1 to 1.54 t/ha with VC 3116-B-5-B producing a significantly higher yield than check BPI Mg2 with 1.3 t/ha. Lower mean yields were obtained during the wet season because of adverse climatic conditions.

Seeds of all the test entries in both seasons were bigger than those of the two check cultivars, Pag-asa 1 (4.30 to 4.03 g/100 seeds) and BPI Mg 2 (5.43 g/100 seeds, dry season to 4.33 g/ 100 seeds, wet season). However, VC 3039-B-4B produced the biggest seed size of 6.93 g/100 seeds during the wet season.

Almost all entries showed moderate to high resistance to CLS in both seasons, except Sel. 206 which was rated 4.67 or highly susceptible. Viruses were also observed during the early stage of the plant.

Set G. Forty lines selected from the previous evaluation and selection trials underwent PYT during the 1985 dry and wet seasons (Table 1). In the dry season, 15 test entries with mean bean yields ranging from 0.6 to 0.8 t/ha significantly outyielded the check variety PBI Mg2 with 0.4 t/ha. VC 3061-7-1-1-1-B gave the highest yield closely followed by VC 3027-6-2B-1-B and VC 3121-2B-1-1-B. The grand mean was 0.5 t/ha.

During the wet season, 13 entries surpassed the yield of the check variety Pag-asa 3 (1.2 t/ha). However, there was no significant yield difference among the 40 entries. The five highest yielders were: VC 3012-5-2B-2-B, VC 3096-2B-1-2B, VC 3108-2B-1-2B, VC 3016-2B-1-2B, and VC 3027-6-2B-1-B with mean bean yields of 1.5, 1.5, 1.4, 1.4, and 1.3 t/ha, respectively. The wet season grand mean was 206% over the dry season mean.

Conclusion

Since varieties in PYT, set E, had undergone four seasons of trials, the two most outstanding lines will be elevated to the Regional Yield Test. The other promising lines will be included in the general yield trial next season.

Table 1. Field performances of the five highest yielding entries in the preliminary yield trials at the Economic Garden.[z]

Entry	Yield (t/ha)	100-Seed Wt (g)	Pods/Plant	Disease Rating[y]
Dry Season				
VC 3061-7-1-1-1-B	.78	6.0	7.05	3.5
VC 3027-6-2B-1-B	.74	5.3	6.95	2.5
VC 3121-2B-1-1-B	.71	5.1	8.80	3.0
VC 2851-9-2-1-1-2B	.71	6.1	7.35	4.5
VC 3108-B-1-1-2B	.70	4.6	7.50	4.0
BPI MG2 (Ck)	.43	5.4	7.70	4.0
Pag-asa 3 (Ck)	.36	4.3	7.90	5.0
Grand Mean	.54	5.46	7.53	3.54
LSD 5%	.15	4.10	ns	1.20
1%	.20	5.46	ns	1.59
CV (%)	14.08	1.19	14.32	16.86
Wet Season				
VC 3012-5-2B-2-B	1.51	4.95	11.7	1.5
VC 3096-2B-1-2B	1.47	5.90	14.3	1.0
VC 3108 2B-1-2B	1.42	5.20	12.3	1.0
VC 2762 B-67-B-1-B	1.35	5.30	10.6	1.5
VC 3027-6-2B-1-B	1.35	5.30	12.9	1.0
Pag-asa 3 (Ck)	1.21	4.00	14.9	1.5
BPI Mg2 (Ck)	1.15	5.30	11.7	2.0
Grand Mean	1.11	5.40	12.65	2.9
LSD 5%	ns	.22	ns	1.01
1%	ns	.30	ns	ns
CV (%)	22.03	2.05	21.45	17.46

[z]Dates of planting = 14 Nov. 1984 (dry season) and 5 June 1985 (wet season); data mean of 5 sq m subplots; design = randomized complete block replicated three times; plant density = 300,000 plants/ha; fertilizers = 30 kg each of N, P_2O_5, and K_2O at planting; insecticides = Lannate and Thiodan at 30 cc/4.5 liters of water were sprayed alternately at 10-day intervals up to late pod development stage. [y]For the dry season, disease (PM) incidence was rated on a scale of 1 to 5, with 1 = highly resistant, to 5 = highly susceptible; for the wet season, virus incidence was rated on a scale of 1 to 3, with 1 = resistant, to 3 = susceptible.

General Mungbean Yield Trial

Introduction

Promising lines after two to four seasons of preliminary yield trials (PYT) are entered in the general yield trial (GYT).

Materials and Methods

For 1985, 17 entries were evaluated during dry and wet seasons. Each entry was set in a four-row, five-m-long subplots distributed in a randomized complete block design and replicated three times. The rows were set 50 cm apart. Other standard cultural practices for mungbean were followed.

Results and Discussion

For the dry season, VC 1973-A produced the highest yield of 1.4 t/ha. The grand mean was 1.2 t/ha among the 17 entries. Although no significant differences were obtained between mean yields, four entries with yields ranging from 1.3 to 1.4 t/ha outyielded the higher yielding check (M650-10A) with 1.3 t/ha.

During the wet season, bean yield varied from 0.4 t/ha to 0.9 t/ha, with a grand mean of only 0.6 t/ha (Table 2). Eight test entries (V 1628-A, V 1973-A, V 2768-A, V 2707-28-2-B, V 2747B-9-2B(s), V 2707-A, VC 2762-4-B-2-B, and V 2719-A) significantly outyielded the highest-

yielding check cultivar MG50-10A (0.5 t/ha). These lines produced yields ranging from 0.7 to 0.9 t/ha. Excessive rains brought about by several typhoons during the entire crop season greatly affected the plant stand and quality of the seeds.

Significant differences were also obtained in almost all the yield components and other agronomic characters measured. Generally, all the entries produced smaller seeds during the dry season (5.03 g/100 seeds). Incidence of CLS infection was higher in the DS than during the WS. Virus was also observed in all entries during the early stage of crop development.

In 1983, five promising lines selected from the GYT were included in the regional yield trial (RYT). After two years of evaluation in 6 to 10 locations, two entries (EG 2764 and EG 2755) were recommended in 1985 for seed increase in preparation for its possible recommendation by the seed board in 1986 (Table 3).

Table 2. Field performance and other agronomic characters of the most promising AVRDC mungbean entries evaluated in the GYT during the dry and wet seasons of 1985 at the Economic Garden.[z]

Entry	Yield (t/ha)	100 Seed Wt (g)	Pods/ Plant	Disease Rating Virus[y]	
Dry Season					
VC 1973 A	1.44	6.3	11.17	1.33	
VC 2778-3-B-1-B	1.43	6.6	11.33	1.33	
VC 2707-A	1.26	4.8	11.87	1.33	
VC MG50-10A (Ck)	1.25	6.6	10.77	1.00	
Pag-asa 3 (Ck)	1.21	4.1	0.97	1.00	
Grand Mean	1.18	5.82	10.61	1.16	
LSD 5%	ns	.12	ns	ns	
1%	ns	.16	ns	ns	
CV (%)	16.67	1.25	15.08	37.8	
Wet Season				Virus[x]	CLS[x]
VC 1628-A	.91	5.27	10.20	2.67	3.67
VC 1973-A	.87	5.50	7.10	2.00	2.67
VC 2768-A	.82	5.73	8.00	1.67	2.33
VC 2707-2b-2-b	.80	4.93	8.77	2.00	2.00
VC 2767-4-b-2-b	.72	5.03	9.53	2.00	2.67
Grand Mean	.64	5.03	9.24	2.18	2.33
LSD 5%	.17	.13	2.57	ns	.87
1%	.22	.17	ns	ns	1.12
CV (%)	15.67	1.54	16.70	18.35	21.50

[z]Dates of planting: 31 Jan. 1985 (dry season) and 29 July (wet season); data are means of 5 m^2 subplots; design: randomized complete block with three replications; plant density: 300,000 plants/ha; fertilizers: 30 kg each of N, P_2O_5, and K_2O at planting; insecticides: Lannate and Metasystox-R at 30 cc/4.5 liters of water sprayed at 10 day intervals up to late pod development stage. [y]Rated on a scale of 1 to 5, with 1 = highly resistant to 5 = highly susceptible. [x]Rated on a scale of 1 to 3, with 1 = resistant to 3 = susceptible.

Table 3. Comparative yield performance (t/ha) of first three promising mungbean entries in the regional yield trial of 1983-84 and 1984-85.

Entry	1983-84		1984-85		Mean	
	WS[z]	DS[y]	DS[x]	WS[w]	WS	DS
IPBM 7913-60	1.54(2)	1.01(5)	1.56(4)	0.89(4)	1.55(1)	0.95(2)
EG 2775	1.34(6)	1.06(2)	1.56(3)	0.84(3)	1.45(3)	0.95(2)
EGM 2764	1.43(5)	1.07(1)	1.59(1)	0.95(1)	1.51(2)	1.01(1)
Check variety	1.24(11)[v]	0.97(7)[v]	1.42(12)[u]	0.82(13)[u]	1.33(4)	0.90(3)

[z]Mean of seven locations. [y]Mean from eight locations. [x]Mean of 10 locations. [w]Mean of six locations. [v]MG50-10A. [u]Pag-asa 3. Note: Numbers in parentheses are ranks of the entry in the trial.

Conclusion

Because of their outstanding performances, two lines EG 2755 and EG 2764 will be recommended to the Philippine Seed Board for release as commercial varieties.

13th International Mungbean Nursery

Introduction

The International Mungbean Nursery (IMN) is an international cooperative trial currently coordinated by AVRDC. Its objectives are to provide information in the range adaptation of mungbean species and specific cultivars, provide information regarding the characteristics of mungbean influencing adaptation, and serve as a means of disseminating superior cultivars to mungbean researchers.

Materials and Methods

Twenty elite cultivars, lines, or hybrids from different countries (Taiwan, China 14; Rep. of Korea, 1; Philippines, 2; and India, 2) were planted on 30 October in 2.0 m x 5.0 m subplots arranged in a randomized complete block design and replicated three times. The furrows were set 50 cm apart. Complete fertilizer (14-14-14) was applied at 0.3 t/ha at planting. The crop, at a density of about 300,000 plants/ha, was raised and data collected according to the AVRDC standard procedure for mungbean evaluation trials. This study is still in progress.

Evaluation of AVRDC Soybean Breeding Lines

Introduction

This study was conducted to determine high bean yield potential, resistance to major foliar diseases, and adaptability to agro-climatic conditions of AVRDC lines/accessions.

Materials and Methods

A total of 58 AVRDC lines/accessions were evaluated against the check varieties BPI-Sy2 and UPL-Sy2 during the dry and wet seasons of 1984-85. The evaluation was conducted in nonreplicated 5-m-long plots with two rows each. Another set of 178 AVRDC lines was planted on 2 July, in the wet season.

Results and Discussion

No computed bean yield was obtained in the trials of both seasons because of poor germination. Only 45 and 35 lines/accessions germinated during the dry and wet seasons, respectively. Data on days to emergence, flowering, and maturity; number of pods; 100-seed weight; and soybean rust ratings were taken.

The wet-season replicated trials were unfortunately damaged by the three successive typhoons that occurred after planting. As a result, only 94 lines were harvested and seeds were saved for further evaluation in the dry season.

Conclusion

No yield was computed because of poor germination and typhoons.

Preliminary Soybean Yield Trial

Introduction

A total of 56 soybean entries were evaluated during the dry and wet seasons. The emphasis was on yield and resistance to rust.

Materials and Methods

AVRDC-recommended standard procedures for evaluating soybean were followed.

Results and Discussion

Highly significant differences in bean yield and in most characters were found among entries measured during the dry season (Table 4). Out of the 26 entries tested, 13 significantly outyielded the highest-yielding check BPI-Sy2. Bean yield ranged from 0.33 to 1.17 t/ha with a grand mean of 0.89 t/ha for the 26 entries. Line G 90089 gave the biggest seed size of 18.4 g (100-seed weight). The entries were rated resistant and moderately resistant to rust under natural field infection.

Of the 30 entries evaluated against three checks during the wet season, only six outyielded the higher yielding check BPI-Sy4, but yield differences were not statistically significant. The grand mean yield for all entries was 1.76 t/ha. Significant differences were obtained in other yield components measured. All the entries were rated moderately resistant to moderately susceptible to soybean rust.

Entry G 90089 gave consistently high bean yields during the dry and wet season trials.

Table 4. Bean yield and some agronomic characters of AVRDC soybean lines/accessions evaluated in the preliminary yield trial during the dry and wet seasons of 1984-1985.[z]

Entry	Bean Yield (t/ha)		100-Seed Wt (g)		Days to Maturity		Seed Quality		Rust Rating	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
1. G 90089	1.17**	2.28	18.4	20.7	82	102	2.3	4.0	2.7	3
2. GC 60017-2-2	1.15**	1.92	13.6	13.2	75	96	2.3	2.5	3.0	3
3. G 90088-8	1.10**	1.66	15.1	16.2	81	96	2.0	2.5	3.0	3
4. GC 30265-2-18-7	1.05**	1.84	18.1	16.2	77	93	2.0	2.5	3.0	3
5. G 0062	1.03**	1.70	17.2	18.9	80	113	2.0	2.5	2.3	3
6. G 90074	1.04**	2.23	15.8	15.5	84	105	2.3	3.5	2.0	2
7. GC 40359-1-91	0.99**	2.27	15.4	15.5	81	99	2.0	3.5	2.7	3
8. GC 50265-2-18-7	0.99**	1.86	17.9	16.1	76	96	2.0	2.0	3.0	3
9. BPI-12A-11	0.99**	1.16	13.8	15.4	82	101	2.0	3.0	2.3	2
10. SJ 4	0.96*	2.23	10.8	15.0	82	104	2.7	2.5	3.0	3
BPI-Sy2 (Ck)	0.76	1.63	12.8	13.7	84	104	2.0	3.0	2.7	3
BPI-Sy4 (Ck)	–	2.03	–	13.7	–	97	–	2.5	–	3
Grand mean										
(26 entries)	0.89		14.3		80		2.2		2.7	
(30 entries)		1.76		1.48		100		2.6		2.8
LSD 5%	0.16	0.44	0.94	1.90	1.42	1.82				
1%	0.22	0.59	1.26	2.41	1.90	2.43				
CV (%)	11.29	15.56	4.03	7.87	1.08	1.12				

[z]Dates planted: 4 Dec. 1984 (dry season, DW) and 5 June 1985 (wet season, WS); data mean of 5 sq m subplots; design: randomized complete block replicated four times; plant density: 350,000; fertilizer: 30 kg/ha each of N, P_2O_5, and K_2O at planting; sprayed regularly with insecticides; * = statistically significant over the check BPI-Sy2 at the 5% level; ** = statistically significant over the check BPI-Sy2 at the 1% level.

Conclusion

In the dry season trial 50% of the entries (26) significantly outyielded the highest-yielding check BPI-Sy2 in yield and in most parameters rated. The most stable yielder in both seasons was G 90089.

General Soybean Yield Trial

Introduction

No replicated planting was made during the dry season because of severe drought. The entries were planted for seed increase during the wet season.

Materials and Methods

Eleven entries and two checks were evaluated during the wet season. AVRDC standard procedures for evaluating soybean were followed.

Results and Discussion

The computed bean yield ranged from 0.88 to 2.27 t/ha (Table 5). Although most of the entries outyielded the highest-yielding check, only three gave high significant difference. Line AGS 208 gave the biggest seed size of 24.6 g/100 seeds.

Table 5. Mean bean yield and other agronomic characters of promising AVRDC lines and accessions in the general yield trial, wet season 1985.[z]

Entry	Plot Yield[y] (t/ha)	100-Seed Weight (g)	Days to flowering	Days to maturity	Ht at Maturity (cm)	No. of Pods/ Plant	Plants Harvested	Disease Rating Rust	Disease Rating SMV	Lodging	Seed Qlty.
G 90107	.88	16.1	31	97	62.7	99	24	4	1.7	2.7	2.5
GC 50123	1.71*	9.3	42	94	107.7	86	107	4	1.5	4.0	2.5
GC 30187-10-9	1.29	11.7	34	95	37.2	80	67	3	1.3	2.0	3.0
GC 50225-1-6	1.64	14.6	39	96	85.5	128	56	4	1.8	3.7	2.5
GC 50193-7-6	1.99**	9.3	39	95	70.1	71	122	4	1.3	3.7	2.5
GC 50095-7-0-9	2.02**	10.9	36	90	61.3	87	88	4	2.0	3.3	2.5
ISRA IRAT 44A	1.33	11.7	38	100	41.6	151	37	4	1.2	2.0	2.0
IAC 73-5115	1.03	17.5	37	100	39.9	83	53	3	1.5	2.0	2.5
AGS 129	1.44	15.9	27	93	48.1	85	40	4	1.3	2.0	2.5
AGS 133	2.27**	18.7	30	83	44.3	44	132	3	1.0	2.0	2.5
AGS 208	1.26	24.6	28	84	29.5	47	48	3	2.7	1.5	3.0
UPL-Sy2	1.13	17.1	31	91	51.7	79	58	3	2.7	1.7	3.0
BPI-Sy4	1.10	15.1	31	93	50.5	90	58	3	2.7	2.2	2.5
Grand Mean (13 ent.)	1.47	14.8	34	93	56.14	87	68	3.5	1.7	2.5	2.6
LSD 5%	.58	2.07	0.37	1.00	14.47	30.56	36.13				
1%	.79	2.81	0.51	1.36	19.62	41.42	48.96				
CV (%)	23.56	8.3	0.65	0.64	15.30	20.85	31.5				

[z]Date of planting = 30 July, 1985 (wet season, WS), data mean of 6 sq m subplot; design = randomized complete block with three replications; plant density = 350,000/ha; fertilizers = at 30 kg/ha each of N, P_2O_5, and K_2O at planting; sprayed with insecticide regularly. [y]Significant over the check UPL-Sy2 at the 5% level = *; Significant over the check UPL-Sy2 at the 1% level = **.

Conclusion

So far, AGS 133 outperformed the checks and the rest of the entries in terms of yield and other yield parameters.

Asian Soybean Evaluation Trial (ASET)

Twelve lines/accessions were evaluated in replicated trials during the wet season. Planting was done on 2 July 1985. However, due to the three successive typhoons that occurred after planting, no result was obtained from the trial. The same entries from AVRDC were again planted on 8 October for the dry season. As of mid-December, the plants were still in their reproductive stage. Unfortunately, all the entries were severely infected with soybean rust and bacterial pustule. Results of bean yield and other yield components will be reported later.

Regional Performance Test of AVRDC Soybean Lines

Introduction

From several hundred AVRDC segregating lines evaluated from 1976 to 1984, three promising lines (AGS 19, AGS 73, and GC 30293-6-10) were selected for inclusion in the regional yield trial.

Materials and Methods

Eleven entries and two checks were evaluated during the wet and dry seasons for three crop years, 1982-85. The procedures prescribed by the Upland Crops National Cooperative Trial (UCNCT) were used in evaluating the soybean entries.

Results and Discussion

Results from three consecutive years (1982-85) showed that AGS 73 produced mean yields of 2.07 t/ha during the wet season and 1.79 t/ha during the dry season (Table 6). AGS 73 consistently outyielded the highest-yielding check UPL-Sy2 by 2.4% and 5.29% during the wet and dry seasons, respectively. These yields were based on three wet seasons and three dry seasons in 22 locations.

The other outstanding feature of AGS 73 is its long seed viability under ambient conditions. When kept for four months in a porous container at room temperature, it gave the highest germination of 81%, followed by BPI-Sy2 with 67% and UPL-Sy2 with 57%. At six months storage under the same condition, its germination was 64%, while that of BPI-Sy2 and UPL-Sy2 was both 29%.

Table 6. Mean yield, other agronomic characters, and percentage germination of BPI-Sy4 and two check varieties, from three crop years 1982-1985.

Entry	Mean Bean Yields		Days to Maturity		Plant Ht. at Maturity (cm)		Proximate Analysis		Disease Rating			
									Rust Rating		BP[x]	Virus
	WS[z]	DS[y]	WS	DS	WS	DS	% Fat	% Prot.	WS	DS	WS	DS
BPI-Sy4	2.07(1)	1.79(1)	90	85	91	36-50	20.1	34.9	2.5	2.25	1.1	1.8
UPL-Sy2(Ck)	2.02(2)	1.70(2)	92	84	92	55	24.7	38.6	2.3	2.0	1.7	2.75
BPI-Sy2(Ck)	1.91(3)	1.49(3)	100	90	93	60	24.6	43.3	3.0	2.5	1.5	2.75

[z]Mean of 21 locations in the wet season (WS). [y]Mean of 22 locations in the dry season (DS). [x]BP = bacterial pustule.

Conclusion

After three consecutive years of testing, AGS 73 was recommended and approved in 1985 as a Seed Board variety with a new name, cv. Tanco Soy or BPI-Sy4. It is a consistent high yielder with the highest seed-germination rate.

Preliminary Yield Trials for Chinese Cabbage

Introduction

This study was conducted to identify Chinese cabbage entries with stable high yields in both wet and dry seasons.

Materials and Methods

Eleven entries were evaluated on 6 sq m plots arranged in a randomized complete block design replicated four times. The entries were transplanted on 19 December 1984 (dry season) and 11 July 1985 (wet season).

Results and Discussion

The computed marketable head yield during the dry season ranged from 8.5 t/ha (#8144) to 23.8 t/ha (CAT 80-33) which was the only entry to outyield check B189 C1 (15.8 t/ha). During the wet season the yield ranged from 9.7 t/ha (CAT 80-39) to 17.3 t/ha (CAT-80-32). The grand mean was 7.8 t/ha for the eleven entries. Three entries (CAT 80-32, CAT 80-33, and CAT 80-37) significantly outyielded check B189 C1.

The grand head weight means were 670 and 484 g for the dry and wet seasons, respectively. There were significant differences among entries for head weight in both seasons, but none for solidity.

Entry CAT-80-13 and the check B189 C1 produced the highest harvest rate of 97% during the dry season, while CAT 80-37 was the highest with 93% during the wet season.

Conclusion

Three entries significantly outyielded B189 C1 in the wet season.

General Yield Trials for Chinese Cabbage

Introduction

Promising selections from the previous preliminary yield trials were further tested against two checks to determine yield, head weight, harvest rate, and solidity of five Chinese cabbage.

Materials and Methods

Five promising entries (CAT 80-32, CAT 80-33, CAT 80-37, CAT 80-38, CAT 80-39) were evaluated against two checks; Reyna Elena, a new Seed Board variety, and B-32, a standard check. The entries were transplanted to 12 sq m plots on 28 December 1984 (dry season) and 29 January to 7 February 1985 (wet season). The design was randomized complete block with four replications.

Results and Discussion

During the dry season, entry CAT-80-39 produced the highest marketable head yield of 20.1 t/ha which was not, however, significantly different from that of Reyna Elena (17.4 t/ha). In the wet season, marketable head yields ranged from 14.1 t/ha (check B-32) to 18.8 t/ha (Reyna Elena) with a grand mean of 16.9 t/ha.

The highest head-weight mean was obtained from CAT 80-39 with 608 g (dry season) and from Reyna Elena with 604 g (wet season). The grand harvest-rate mean during the dry season was higher with 96% as against 86% in the wet season.

Conclusion

In the overall analysis, the field performances of all the entries were comparable to that of the Seed Board check, Reyna Elena.

Chinese Cabbage Seed Production

Introduction

After cv. Reyna Elena was released by the Philippine Seed Board, a preliminary study on seed production was jointly conducted by POP and the BPI Baguio Experiment Station from November 1984 to April 1985. The study aimed to determine the feasibility of producing hybrid seeds of Reyna Elena with the techniques developed at AVRDC.

Materials and Methods

Seeds of the parent lines of ASVEG 1 were sown in petri dishes and allowed to germinate for about 24 to 36 h at room temperature. The germinating seeds were then placed in the vernalization chamber at a temperature range of 5° to 10°C in continuous light for 25 days. After vernalization the seedlings were pricked in flats and hardened under partial shade for 18 days, then transplanted to the field in 1 m x 12.8 m plots at a 1:1 male-female ratio.

A month after transplanting, the terminal buds of the main stalk were pinched to induce production of lateral flower stalk. Hand pollination was done instead of bee pollination (because of the unavailability of bees) 10 days after pinching.

Results and Discussion

Changes and adjustments in the schedule of activities were made due to some constraints. Diamondback moth attacked the young seedlings, but this was controlled although plant stand was affected. The colony of lowland bees intended for the study died a week after it was brought up to Baguio. Therefore, hand pollination was resorted to in the production of Reyna Elena seeds and in the maintenance of parent inbred lines which were kept in separate cages.

The hybrids produced from this project gave 100% germination in the laboratory test. Test of sibbing rate which requires at least 500 seeds taken at random from each parental line will be done later.

Conclusion

This preliminary study showed that the Chinese cabbage seed-production technology developed at AVRDC can easily be adapted here under Philippine conditions. This study is being duplicated and verified in a larger field and under less-controlled conditions to determine its economic feasibility before passing the technology on to prospective private seed growers. Sowing and vernalization of seedlings were done in November 1985, and the study is expected to be completed in April 1986.

Single-Seed-Descent (SSD) Trial for Tomato

Introduction

Single-seed-descent (SSD) entries were seed-increased and evaluated at POP in unreplicated rows. Adapted lines with high marketable yield, good fruit-set, and ideal fruit characters were selected for the preliminary yield trial.

Materials and Methods

In 1985, no new set of SSD materials was received from AVRDC. Instead, more seeds of three promising lines (CL 1131-0-0-43-8-1, CL 1131-0-0-7-2-0-11-0, and CL 5915-93 D6-1-0) were requested from the Center for further trials during the 1985-86 dry season trial.

Results and Discussion

Of the 58 lines of CL 5915 and seven lines of CL 1131 series, 44 lines were selected and have undergone three seasons of preliminary yield trials.

Preliminary Tomato Yield Trial

Introduction

Selected SSD (single seed descent), open-pollinated, and hybrid lines of the fresh market or processing tomatoes were tested under the preliminary yield trial for four seasons (two wet and two dry). The study aimed to identify lines with high marketable yields and desirable agronomic/processing qualities during either the wet- or dry-season planting.

Materials and Methods

For fresh market tomatoes, set 1 was transplanted on 8 October 1984 and harvested three times from December 3 to 26 1984. Set 2 was transplanted on 8 October 1984 and harvested six times from 3 December 1984 to 22 January 1985. The third set was transplanted on 11 February 1985 and harvested five times from 2 to 19 April 1985. The wet season trial was planted in 10 m^2 subplots arranged in a randomized complete block design (RCBD) with four replications. It was transplanted 17 May 1985 and harvested three times from 25 July to 5 August 1985.

For processing tomatoes, the entries were transplanted on 17 December 1984 on 5 m^2 subplots with 15 hills/row arranged in RCBD with two replications.

Results and Discussion

Fresh-market tomatoes. Forty-four breeding lines were evaluated in three sets during the 1984-85 dry season. Yields were not significantly different from each other within each set. Mean yields in tons per hectare within each of the three sets were 5.89, 6.51, and 25.0 for sets 1, 2, and 3, respectively. The selected lines were reevaluated during the wet season. Four lines CL 5915-445 (G) D4-1, CL 5915-217 (G) D4-1, CL 5915-362 (G) D4-1, and CL 5915-153 (G) D4-2) showed highly significant yield differences over the check Marikit.

Table 7 shows the yield and other horticultural characters of a new set of entries under the first preliminary trial. The entries flowered from 27 to 32 days after transplanting and had a grand mean fruit set rate of 3.06. Fruit size varied from 21 to 62 g per fruit, with the biggest observed on CL 5915-93 D6-1-0. The reactions to pest (fruit worm), diseases (bacterial wilt and bacterial leaf spot), and physiological disorders (cracking and stem scald) varied, but did not show any significant differences.

Highly significant differences were observed on marketable and nonmarketable fruit yields, with the highest total recorded on CL 5915-93 D6-1-0 (26.56 t/ha) as against 9.52 t/ha of the check Marikit.

Processing tomato. During the 1984-85 dry season, several sets of processing tomato lines were evaluated in a preliminary yield trial to determine the yield performance of open-pollinated and F1 hybrids. The check Marikit produced the highest yield; L 389 had the biggest fruits; and L 345 was the least susceptible to bacterial wilt.

Table 7. Yield and some horticultural characters of fresh market tomato in a wet-season preliminary yield trial, 1985.[z]

Entry	No. of Days to Flowering	Yield (t/ha) Marketable	Nonmarketable	Total	Fruit-Set Rating	Fruit Size (g)	Disease Rating[y] BW	BLS	Cr	SS	FW
CL 1131-0-0-43-8-1	27	18.38*	2.7	21.08	3.3	36*	2.0	5.0	1.58	1.05	1.22
CL 1131-0-7-2-0-11-0	29	18.37*	1.77	20.14	3.7	41**	2.3	5.0	1.34	1.05	1.34
CL 143-0-10-3-0-1-1-0	27	13.47	0.89	14.36	2.3	31	2.0	5.0	1.05	0.71	1.22
CL 5915-183 D4-3-4	29	9.11	0.99	10.1	3.0	31	2.3	5.0	1.05	1.34	1.22
CL 1131-0-0-65-1-13-0-1	27	15.47	1.43	16.9	3.7	27	2.7	5.0	0.88	1.34	1.05
CL 5915-229 D6-1-4	30	6.07	1.05	7.12	1.7	23	3.0	5.0	0.88	1.0	1.46
CL 5915-93 D6-1-0	23	21.43**	5.13**	26.56	4.0**	62**	1.7	4.7	1.58	0.88	1.22
CL 5915-153 D6-3-3	32	6.7	0.89	7.59	3.3	27	2.3	4.7	1.05	1.56	1.05
CL 5915-222 D6-0-5	28	7.1	0.67	7.77	2.3	21	2.7	5.0	0.88	1.22	1.34
CL 1131-0-0-13-0-6	28	13.43	4.1**	17.53	3.7	27	2.7	4.7	1.46	1.34	1.22
Marikit (Ck)	29	8.63	0.89	9.52	2.7	27	2.7	4.3	1.17	1.05	1.34
Grand Mean	28.5	12.56	1.86		3.06	32.1	2.4	4.85	1.17	1.14	1.24
LSD 5%	1.84	8.09	1.0		1.13	8.9	ns	ns	0.42	ns	ns
LSD 1%	2.5	11.04	1.37		–	12.1	ns	ns	0.57	ns	ns
CV (%)	3.8	38	31.8		21.6	16.2	19.1	9.5	20.9	24.8	13.97

[z]Data are means of three replications arranged in a randomized complete block design with subplots of 10 m²; transplanted 16 May 1985; harvested four times from July 18 to Aug. 1985. [y]Rating from 1 to 5 in an increasing order of severity; data for Cr, SS, and FW were transformed to $\sqrt{x + 0.5}$ prior to ANOVA.

In another trial, six F1 hybrids were compared to cvs. Taiwan Selection and Marikit, both open-pollinated varieties. A highly significant difference in yield was observed on PT-1017 with 43.18 t/ha against Marikit with 31.34 t/ha. Flowering varied from 28.8 to 32 days. Highly significant differences on fruit size were observed with biggest fruits produced by PT-857, PT- 878, and PT-778; fruits of Tainan Sel were significantly big; bacterial wilt was not severe; and the lowest score of 0.71 was noted on PT-857, PT-1017, and PT-1599.

The third set of processing tomato lines was composed of F1 hybrids and open-pollinated lines. The highest yield of 30.88 t/ha was produced by PT-774 (F1), but the yield difference over the check was insignificant. Fruit-set score of 4.2 was recorded on TK 70, a standard variety of Taiwan. The biggest fruit size of 117.2 g/fruit was produced by PT-1461 (open-pollinated). The reaction of the entries to bacterial wilt varied with the highest incidence (2.07) on TK 70 and the lowest (1.06) on PT-1498 (open-pollinated).

The marketable yields of F1 hybrids were higher than those of the open-pollinated cultivars, but the differences were insignificant.

Conclusion

After two seasons of field trials, eight promising fresh market tomatoes have so far been identified. These were CL 5915- 362 (G) D4-1, -222 (G) D4-0, -369 (G) D4-1, -445 (G) D4-1, -223 (G) D4-2, -197 (G) D4-1, -153 (G) D4-2, and -217 (G) D4-1.

On the processing tomatoes, the selected F1 hybrids were PT 1017, PT 3027, and PT 1599. Seeds of these hybrids were requested from the Center for further field trials.

General Tomato Yield Trial

Introduction

Selections from the PYT were further evaluated in the general yield trial for another two wet and two dry seasons. The objectives were to further screen the fresh market tomatoes for yield, heat tolerance, and resistance to pests and diseases during the wet and dry seasons; and the processing tomatoes for yield, processing qualities (pH, high solid color, etc.) during the dry season.

Materials and Methods

The dry season trial consisted of 15 entries planted in a 5 m^2 subplot and harvested from 13 February to 11 March. The first wet season trial is composed of 10 entries planted in a 10 m^2 subplot and harvested from 25 July to 5 August. The second wet season trial had eight entries planted in a 5 m^2 subplot and harvested from 16 October to 4 November.

Results and Discussion

The entries were tested once during the dry season and twice during the wet season. The results of the trials are presented in Table 8. During the dry season, CL 143-0-1-3-3-1 (38.3 t/ha) outperformed the check, Marikit (31.85). The two wet-season tests showed that CL 551-6-0-18-1-1 and CL 1344 F5-78 significantly outyielded the check in both trials. These two lines were planted for seed production this season (1985-86) for submission to the regional trial in the 1985 wet season.

Table 8. Yield (t/ha) of AVRDC fresh-market tomato lines in the general yield trials.

Entry	Dry Season[z]	Wet Season		Mean
	12/17/84	5/16/85[y]	8/14/85[x]	
CL 143-0-1-3-3-1	38.3	4.8	14.2	9.46
CL 551-6-0-18-1-1	36.57	10.45**	22.07**	16.26
CL 8d-0-7-1-0-0-1	26.97	2.75	7.22	4.99
CL 9-0-0-1-3	36.02	1.1	6.6	3.85
CL 1344 F5-48	32.45	1.4	16.6	9.00
CL 1344 F5-78	32.40	5.67**	19.54**	12.61
Marikit (Ck)	31.85	3.6	10.27	6.94
Grand Mean	33.10	4.2	13.3	
LSD 5%	9.17	1.45	4.84	
VC (%)	19.38	20.2	24.79	

[z]Composed of 15 entries; data are means of 5 m^2 subplots; harvested eight times from 13 Feb. to 11 Mar. 1985. [y]Composed of 10 entries; 10 m^2 subplot area; harvested three times from 25 Jul. to 5 Aug. 1985; ** = significant at the 1% level. [x]Composed of eight entries; 5 m^2 subplot area; harvested six times from 16 Oct. to 4 Nov. 1985.

Conclusion

After four seasons of GYT, three fresh market tomatoes (CL 1094-88, CL 1344-48, and CL 1344-78) were submitted in 1986 for inclusion in the regional yield trial.

Regional Tomato Yield Trial

Introduction

All promising vegetable lines developed and/or selected by the breeding station have to undergo regional yield trial (RYT) before the lines are released for commercial production. The RYT is conducted in seven to ten stations throughout the country and is coordinated by the National Coordinated Trial (NCT) for vegetable crops.

Materials and Methods

Lines selected from the GYT are evaluated under the RYT for two wet and two dry seasons. Participating stations follow the same standard cultural management practices and procedures in evaluating the entries as prescribed in the NCT. The important parameters used in evaluating the entries

are marketable yield, horticultural/botanical characters and reactions to insect pests and diseases. The results of four seasons, RYT, and at least one season in the farmer's field are used as basis for recommending the line for approval by the Philippine Seed Board.

Results and Discussion

During the 1984 wet season, eight fresh-market tomatoes were evaluated in seven stations. Only four stations have completed their reports. Based on these reports, five entries outperformed BPI Tm-1 (check). These were UPL Tm-6, UPL Tm5, AVR-4 (CL 1104-0-0-63-3-1), AVR-3 (CL 143-0-10-3-1), and AVR-2 (CL 641-1-1-1-7-2) with computed yields of 20.6, 17.2, 16.8, 13.2, and 13.0 t/ha, respectively. The check BPI Tml produced 12.6 t/ha.

For processing tomatoes, four lines were submitted to the National Cooperative Testing (NCT) for the 1984-85 dry season. Eight entries were evaluated in seven testing stations, however, only four stations were considered because two did not evaluate their set of materials, and one produced a very high CV of 46.42%. Six entries outyielded the check Roma VF. The entries were CL 2815-1-1-7 (30.85), CL 2784-1-1-4 (37.5), CL 2784-1-1-2 (36.6), CL 2784-1-2-5-2 (35.9), VF 9209 (35.3), and Chico 111 (33.7).

Conclusion

Out of the eight processing tomato entries evaluated in the RYT during the 1984 wet season, the four highest yielders were from the AVRDC lines which significantly outyielded the check Roma VF.

Sweet Potato Germplasm Collection

At present, a total of 160 sweet potato lines/cultivars/ accessions from local and foreign sources (mostly from AVRDC) are maintained in the station. This collection serves as a source of research and production materials for both government and private agencies.

Preliminary Sweet Potato Yield Trials

Introduction

The preliminary yield trial is a component of breeding work. It provides the information of the first series of varieties that should undergo the advance selection stage. The root yield potential and desirable characteristics of sweet potato varieties/accessions from the germplasm collection are initially taken in this activity.

Materials and Methods

Data means of 6 sq m subplots distributed in a randomized complete block design and replicated three times were computed. The wet season trial was planted on 22 August 1984 and harvested on 16 January 1985.

Results and Discussion

Forty-nine new entries from the germplasm collection were evaluated in two sets of trials during the 1985 dry and wet seasons. In set 1, entries were evaluated during the 1984-85 dry season. The low grand mean yield of 4.33 t/ha was due to drought during the crop season. Only CI 946-30 with 7.4 t/ha outyielded the check BNAS (7.2 t/ha), but the difference was not statistically significant. No significant differences were observed on the nonmarketable root yields which gave a grand mean of 0.43 t/ha.

In set 2 with 33 entries, seven showed high significant differences over the control (Table 9). The highest yielder was CI 983-4 with 27.9 t/ha as against 12.0 t/ha of the check BNAS. Two entries CI 953-22 and CI 1088-11, which produced highly significant marketable tuber yields over the check also gave high nonmarketable tuber yields. CI 983-4 and CI 1139-17 significantly produced longer root lengths over BNAS.

Set 3 with 26 entries was planted on 13 August 1985 for the dry season. The study is still in progress.

Conclusion

In set 2, seven entries had highly significant yields over the control BNAS.

Table 9. Seven promising entries of sweet potato in the preliminary yield trial (set II), 1984-85.[z]

Entry	Wt of Marketable Tubers[y] (t/ha)	Wt of Non-marketable Tubers (t/ha)	Root Length (cm)	Root Diameter (cm)
CI 983-4	27.9**	1.9 ns	15.32*	4.97 ns
CI 1124-4	26.9**	1.9 ns	11.81 ns	4.95 ns
CI 1122	26.7**	1.7 ns	13.94 ns	4.96 ns
CI 953-22	23.7**	2.1**	13.19 ns	4.97 ns
CI 1062-2	23.6**	0.5 ns	11.52 ns	6.22 ns
CI 1139-17	23.5**	0.8 ns	14.70*	5.71 ns
CI 1108-11	20.7**	3.0**	11.53 ns	5.02 ns
BNAS (Ck)	12.0	1.0	12.04	5.37
Grand Mean (33 entries)	12.3	1.01	12.21	4.81
LSD 5%	5.353	0.693	2.481	0.865
1%	8.444	0.920	3.279	1.15
CV (%)	31.64	39.65	12.45	11.02

[z]Data mean of 6 m^2 subplots distributed in a randomized complete block design and replicated three times. Wet season trial was planted on 22 Aug. 1984 and harvested on 16 Jan. 1985. * = significant at the 5% level; ** = significant at the 1% level; ns = not significant.

General Sweet Potato Yield Trial

Introduction

The promising sweet potato entries from the preliminary yield trial undergo another set of testing under the general yield trial (GYT). The GYT is the stage of varietal selection prior to inclusion of varieties for regional testing.

Two AVRDC accesssions (I 367 and CI 693-9) which were approved by the Philippine Seed Board for commercial production underwent this trial. Both of these varieties were promising during the PYT and GYT prior to inclusion for regional performance test.

Materials and Methods

Data are mean of 6 sq m subplots distributed in a randomized complete block design replicated four times. This dry season trial had 11 entries planted on 8 October 1984 and harvested on 29 January 1985.

Results and Discussion

Eleven entries were evaluated in the general yield trial during the 1984-85 dry season. Four promising entries, CI 693-9, CI 949-1, CI 951-6, and CI 960-18 with marketable tuber yields of 34.2,

26.5, 26.2, and 25.4 t/ha, respectively, showed significant differences over BNAS (check) which produced 16.8 t/ha. Moreover, mean root diameters of the four entries which ranged from 5.93 to 7.32 cm were larger than those of the control.

On nonmarketable tuber yield, only CI 690-18 produced the highest yield of 1.8 t/ha over the check BNAS (1.5 t/ha), but the difference was not significant.

Conclusion

Four promising entries showed significant tuber yields.

Regional Performance Test for AVRDC Sweet Potato Lines

Introduction

The Philippine Seed Board (PSB) requires that all varieties for release as commercial varieties pass a series of tests for yield and other agronomic characters, resistance to pests, and sometimes quality. The regional testing is the last phase of the requirement wherein the promising AVRDC lines undergo two PYT and GYT cropping seasons.

Materials and Methods

The promising PYT and GYT entries were included for regional testing in different locations identified by the Technical Working Group of Root Crops. The data on high yield and high dry matter content are the main considerations before they can be approved by the PSB for commercial production.

Results and Discussion

Of the 22 entries evaluated in the 1984-85 regional yield trial, two (CI 693-9 and CI 1088-11) were from AVRDC/POP. Line CI 693-9 consistently performed well in terms of marketable tuber yield (14.9 t/ha, mean) from the 21 regional performance tests conducted. For this reason, it was approved by the Philippine Seed Board in June 1985 and was given the commercial name of BPI Sp-2. This variety is now used in the national productivity program of the government.

BPI Sp-2 has 27.2% root dry matter (DM), 21.9% root starch (wet basis), and is moderately resistant to scab. It is adapted to all regions of the Philippines, and is recommended for haman food and animal feed. It has much higher root yield than the recommended variety UPL Sp-1.

Conclusion

CI 693-9 was approved by the Philippine Seed Board and renamed BPI Sp-2.

Evaluation for Weevil Resistance in Sweet Potato

Introduction

Sweet potato is gaining importance in the Philippine economy, hence, the demand to increase production. However, available varieties are beset with problems, especially the presence of weevil, which is the major insect pest of sweet potato in the tropics. The AVRDC sweet potato varieties tested in Taiwan have shown resistance to weevil damage. This study, therefore, further evaluates this resistance under Philippine conditions.

Materials and Methods

Data are means of 6 sq m subplots distributed in a randomized complete block design and replicated two times. The test was conducted during the dry seasons. The entries were planted on 13 November 1984 and harvested on 20 March 1985.

Results and Discussion

Nineteen sweet potato entries were evaluated on their reaction to weevil under natural field infestation. The results of the trial are presented in Table 10.

Ten entries produced marketable root yields (from 10.5 to 15.15 t/ha) which were highly significant over that of the BNAS check with only 4.75 t/ha. However, all these entries were rated susceptible to weevil, except for CI 953-25 which was moderately resistant to this pest.

Conclusion

Ten entries had highly significant yields, but were susceptible to weevil.

Table 10. Performance of sweet potato varieties against weevil.[z]

Entry	Wt of Marketable Tubers[y] (t/ha)	Wt of Nonmarketable Tubers[x] (t/ha)	Weevil Rating[w]
CI 412-2	15.15**	.58 ns	3.5
CI 1103-11	14.65**	.55 ns	4.0
CI 1123-3	14.05**	.35 ns	3.5
CI 953-25	13.70**	.39 ns	2.0
CI 941-32	13.30**	.48 ns	4.0
CI 1028-15	13.00**	.15 ns	3.0
CI 980-16	12.75**	.43 ns	3.0
CI 995-14	12.20**	.40 ns	5.0
CI 1089-2	11.95**	.60 ns	4.5
CI 942-47	10.50**	.43 ns	4.0
BNAS (Ck)	4.75	1.05	4.0
Grand mean (19 entries)	9.98	0.42	–
LSD 5%	4.159	.552	–
1%	5.698	.756	–
CV (%)	19.84	62.54	–

[z]Data are means of 6 m^2 subplots distributed in a randomized complete block design and replicated two times. The test was conducted during the dry season, planted on 13 Nov. 1984 and harvested on 20 Mar. 1985. [y]** = significant at the 1% level. [x]ns = not significant. [w]Rating scale: 1 = no damage; 2 = slight damage, for human food; 3 = moderate damage, for livestock or processing; 4 = moderate to heavy damage, low grade but usable; 5 = very heavy damage, to be discarded or used as fertilizer.

AVRDC-Taiwan, China Outreach Program

Soybean Regional Yield Trials in Taiwan, China

Introduction

In cooperation with District Agriculture Improvement Stations, (DAIS) regional yield trials were conducted in 1984-1985 to evaluate AVRDC, TARI, and DAIS promising lines in the major soybean production area of Taiwan.

Materials and Methods

Three promising AVRDC soybean lines and eight improved lines from TARI, Hualien DAIS, Kaohsiung DAIS, and Chung Shin University were tested against one local check in eight locations for regional yield trials (SRYT) in spring, summer, and autumn, 1984.

The experiment was conducted in a randomized complete block design with five replications. Plot size was 38 m x 34 m. Spacing between rows was 50 cm and between plants within the row was 15 cm in the spring and summer, and 9 cm in the autumn trials.

Results and Discussion

In the 1984 spring trials three AVRDC lines gave lower mean yields than check KS 8 (Table 1). In the 1984 summer trials AGS 129 topped all entries with a mean yield of 2.61 t/ha. In the 1984, autumn trial Hualien 70-40 was the best yielder. The yield differences among all entries, however, were not significant. The results of all three trials pooled together, showed that TARI 4 (2.8 t/ha), KS 8 (2.73 t/ha) and AGS 129 (2.67 t/ha) were the best yielders.

In the 1985 spring trial at AVRDC TARI 4 and AGS 129 were best yielders (Table 2). In the 1985 summer trial at AVRDC KS 1266 (3.43 t/ha) and AGS 133 (3.37 t/ha) gave top yields. The oil content of AGS 129 was the highest of all entries.

Conclusion

Except in the spring, the 1984 trials in Taiwan showed no significant differences in yield among entries. The 1985 data are not yet complete.

Soybean District Yield Trials

Introduction

In cooperation with district agricultural improvement stations (DAIS), AVRDC conducted district yield trials to evaluate promising lines from the last regional yield trials in the major soybean production area of Taiwan.

Table 1. Yield and agronomic characters of entries in the Taiwan soybean regional yield trials, spring, summer and autumn, 1984.[z]

Entry	Spring				Summer				Autumn			
	Yield (t/ha)	DM	Prot. (%)	Oil (%)	Yield (t/ha)	DM	Prot. (%)	Oil (%)	Yield (t/ha)	DM	Prot. (%)	Oil (%)
AGS 129	2.67	113.9	39.2	23.6	2.61	100.6	41.2	23.3	2.73	89.7	38.6	22.7
AGS 133	2.67	110.3	43.4	20.6	2.38	98.5	42.5	21.6	2.57	86.3	40.9	21.0
AGS 157	2.52	119.7	39.4	22.7	2.43	105.7	41.7	22.0	2.63	93.7	36.6	22.3
TARI 4	2.78	116.6	41.5	22.4	2.92	101.6	43.7	22.0	2.70	89.3	41.0	21.3
TARI 5	2.40	115.5	46.6	19.5	2.46	101.3	44.1	21.4	2.58	91.0	42.5	20.5
Hualien 69-7	2.68	110.6	43.7	21.7	2.38	104.5	42.9	22.2	2.44	85.7	41.7	21.0
Hualien 70-40	2.53	112.7	41.6	23.6	2.33	100.8	43.6	22.5	2.88	89.0	41.4	21.7
RM 178	2.64	112.8	43.8	22.8	2.21	101.5	43.0	22.5	2.88	88.3	42.3	21.4
KS 1264	2.65	115.4	44.0	20.3	2.29	104.1	45.8	19.9	2.55	89.3	42.7	20.5
KS 1266	2.66	100.2	41.2	20.6	2.44	99.9	42.3	21.6	2.62	89.7	39.3	20.7
KS 8	2.85	116.5	42.6	20.5	2.47	103.9	45.0	19.7	2.87	91.7	41.7	20.0
R 50	2.27	116.2	44.6	21.9	2.26	101.0	44.6	20.8	2.43	91.0	42.0	20.5
LSD(0.05)	0.20				n.s.				n.s.			

[z]DM = Days to maturity; Prot. = protein; n.s. = not significant.

Table 2. Yield and agronomic characters of entries in the Taiwan soybean regional yield trial at AVRDC, spring and summer, 1985.[z]

Entry	Spring[y]					Summer[x]				
	Yield[w] (t/ha)	100-SW (g)	DM	Prot. (%)	Oil (%)	Yield[w] (t/ha)	100-SW (g)	DM	Prot. (%)	Oil (%)
AGS 129	3.71 a	22.5	126	37.2	23.9	3.27 abc	14.1	99	40.1	25.5
AGS 133	3.46 bcd	27.6	119	43.2	21.0	3.37 ab	15.8	99	43.2	22.0
AGS 157	3.32 d	22.5	126	37.2	23.9	3.17 abc	15.6	106	40.1	23.1
TARI 4	3.73 a	28.0	116	40.8	22.8	3.16 abc	16.4	99	43.3	22.8
TARI 5	3.44 bcd	29.1	117	43.7	20.6	3.17 abc	16.5	101	45.0	21.3
Hualien 69-7	3.23 d	27.2	114	42.6	20.8	2.63 d	17.0	97	43.3	21.8
Hualien 70-40	3.38 cd	24.8	124	43.5	22.9	3.33 ab	16.9	104	43.4	23.7
PM 178	3.32 d	20.8	115	40.6	22.7	3.11 bc	15.9	97	43.8	22.5
KS 1264	3.42 cd	28.8	117	43.3	21.3	3.34 ab	20.3	102	46.2	20.8
KS 1266	3.65 ab	28.5	114	39.8	20.5	3.43 a	16.2	99	42.4	21.7
KS 8	3.60 abc	33.4	120	42.2	20.1	3.21 abc	19.0	104	45.2	20.1
R 50	3.44 bcd	18.7	122	41.8	22.1	3.01 c	15.6	99	44.8	21.4
LSD(0.05)	0.20	1.50	2.30	0.62	0.38	0.25	0.88	1.04	0.59	0.36
LSD(0.01)	0.27	2.01	3.08	0.83	0.51	0.33	1.17	1.39	0.79	0.48

[z]100-SW = 100-seed weight; DM = Days to maturity. [y]Date sown = 24 Jan. 1985; Date harvested = 17-30, May 1985. [x]Date sown = 16 July 1985; Date harvested = 14-23 Oct. 1985. [w]Yields having the same letter in each column are not significantly different at the 5% level according to Duncan's multiple range test.

Materials and Methods

One AVRDC line, one Kaohsiung DAIS line, one Hualien DAIS line, and one TARI line were tested against one local check in 24 locations in the district yield trial (DYT) in spring, summer, and autumn 1984.

The experiment was conducted in a randomized complete block design with three replications. Plot size was 32 m x 37 m. Spacing between rows was 50 cm and between plants within the row was 15 cm in the spring and summer, and 10 cm in the autumn trials.

Results and Discussion

In the 1984 spring trials two AVRDC lines had yields lower than that of check KS 8, but higher than that of check H 15 (Table 3). In the 1984 summer trial AGS 129 and TARI 3 were the best yielders. In autumn 1984 KS 8 was the top yielder and AGS 129 had the highest oil content. In all three trials pooled together AGS 129 (2.04 t/ha), KS 8 (2.04 t/ha), and KS 955 (2.01 t/ha) gave the best yields.

In spring 1985 at AVRDC AGS 129 yielded less than check KS 8, but the differences among all entries were not significant (Table 4). In summer 1985 at AVRDC AGS 129 gave an average yield 15% higher than that of the check and again topped all entries in oil content.

In view of its excellent performance in the 1982-1983 regional yield trials and in the 1984-1985 district trials, AGS 129 was registered as Kaohsiung selection No. 10 on 4 October 1985.

Conclusion

In both regional and district trials, AGS 129 performed best, hence, was released as Kaohsiung selection No. 10.

Table 3. Yield and agronomic characters of entries in the Taiwan soybean district trial in spring, summer, and autumn, 1984[z].

Entry	Spring				Summer				Autumn			
	Yield (t/ha)	DM	Prot. (%)	Oil (%)	Yield (t/ha)	DM	Prot. (%)	Oil (%)	Yield (t/ha)	DM	Prot. (%)	Oil (%)
AGS 129	1.98 b	111.6	41.7	22.8	2.27 a	99.6	41.7	22.8	1.87 b	87.8	37.8	23.1
KS 1058	2.03 b	111.7	40.8	21.8	1.88 b	98.0	40.8	21.8	2.07 a	86.8	39.4	20.7
TARI 3	2.05 b	114.9	43.3	22.1	1.98 ab	95.6	43.3	22.1	1.82 b	87.0	43.0	20.1
KS 8	2.14 ab	113.1	44.7	19.4	1.87 b	102.0	44.7	19.4	2.10 a	89.7	41.6	20.7
Hualien 76-56	2.06 b	113.7	42.9	20.9	1.93 ab	99.0	42.9	20.9	1.71 b	86.2	42.8	20.2
KS 955	2.04 b	10[illegible]	39.1	18.9	1.96 ab	100.8	39.1	21.4	2.03 a	85.8	–	–
R-72	1.57 c	12[illegible]	40.3	22.3	–	–	–	–	–	–	–	–
30104-1-1	2.48 a	112.0	2.0	20.9	1.77 b	97.1	42.0	20.9	1.53 b	87.5	40.4	20.5
H 15	0.92 d	110.0	42.6	16.4	1.39 c	94.0	46.8	17.9	–	–	–	–
Hualien No.1	2.41 a	110.3	–	–	1.70 c	97.5	–	–	0.62 c	86.0	–	–
LSD(0.05)	0.421				0.31				0.21			

[z]DM = Days to malturity; Prot. = protein. Yields having the same letter in each column are not significantly different at the 5% level according to Duncan's multiple range test.

Table 4. Yield and agonomic characters of entries in the Taiwan soybean district trial at AVRDC, spring and summer, 1985.[z]

Entry	Spring[y]					Summer[x]				
	Yield (t/ha)	100-SW (g)	DM	Prot. (%)	Oil (%)	Yield[w] (t/ha)	100-SW (g)	DM	Prot. (%)	Oil (%)
AGS 129	3.27	21.0	121	38.5	24.5	2.74 a	15.6	97	42.0	24.8
KS 1058	3.32	27.1	118	40.1	21.9	2.56 ab	17.0	97	43.2	21.8
TARI 3	3.06	31.1	124	44.6	21.2	2.36 bc	15.9	99	46.2	21.0
KS 8	3.28	34.8	118	42.4	20.2	2.40 bc	20.3	104	46.8	19.4
Hualien 76-56	3.09	30.5	120	43.9	21.4	2.42 bc	18.6	99	45.9	21.5
30104-1-1	3.49	31.9	121	40.6	21.0	2.29 c	16.5	99	44.1	20.6
LSD(0.05)	n.s.	1.60	1.81	0.82	0.63	0.21	1.58	–	0.85	0.54
LSD(0.01)	n.s.	2.27	2.58	1.17	0.89	0.30	2.24	–	1.21	0.76

[z]100-SW = 100-seed weight, DM = days to maturity; Prot. = Protein; n.s. = not significiant. [y]Date sown = 24 Jan. 1985, Date harvested = 20-27 May 1985. [x]Date sown = 16 July 1985; Date harvested = 14-21 Oct. 1985. [w]Yields having the same letter in each column are not significantly different at the 5% level according to Duncans' multiple range test.

Mungbean Regional Yield Trials

Introduction

In cooperation with the Tainan District Agricultural Improvement Station (DAIS), regional yield trials were conducted to evaluate AVRDC promising lines in Chianan area, Taiwan.

Material and Methods

Seven AVRDC promising mungbean lines were tested in regional yield trials against one local check in three locations (spring) and five locations (summer) in 1985.

The experiment was conducted in a randomized complete block design with three replications. Plot size was 26 m x 31 m. Spacing between rows was 50 cm and between plants within the row was 10 cm. Observations were made on a number of agronomic characters.

Results and Discussion

In the 1985 spring trial VC 1168-B and VC 2764-A with yields of 2 t/ha each were the best yielders. VC 1647-B showed top uniform maturity at first harvest (Table 5). In summer 1985 VC 2768-A gave a yield of 2.47 t/ha, which was 14% higher than that of the check, Tainan #3.

The combined results of the 1985 trials showed VC 2768-A and VC 1168-B with average yields which were, respectively, 6% and 4% higher than that of the local check (Table 18).

Conclusion

Trials in two seasons did not show any significant differences in yield among entries and between seasons.

Table 5. Yields and agronomic characters of entries in the mungbean regional yield trials in spring and summer, 1985.[z]

Entry	Spring					Summer				
	Yield (t/ha)	1st Harv. (%)	DM	Plant Ht. (cm)	100-SW (g)	Yield (t/ha)	1st Harv. (%)	DM	Plant Ht. (cm)	100-SW (g)
VC 1000-C	1.97	53.1	81.3	47.0	55.9	2.00	79.4	65.8	74.5	57.5
VC 1168-B	2.07	58.0	79.2	37.7	60.8	2.28	64.7	66.4	75.9	56.8
VC 1647-B	1.86	66.6	78.6	40.0	58.3	1.95	80.9	63.0	70.3	56.8
VC 2530-C	1.93	49.8	80.7	42.9	60.1	1.92	89.4	64.9	76.6	56.9
VC 2572-A	1.93	43.2	81.6	46.9	65.2	2.05	56.3	66.1	83.9	54.8
VC 2764-A	2.04	56.1	80.7	49.3	62.5	2.21	69.5	66.2	85.3	58.6
VC 2768-A	1.93	52.6	79.1	39.4	64.7	2.46	61.1	66.3	79.4	62.5
Tainan No.3	2.00	58.1	79.3	44.3	58.8	2.16	81.1	66.6	78.7	57.1
LSD(0.05)	n.s.	0.87				n.s.	17.10			
LSD(0.01)	n.s.	1.20				n.s.	n.s.			

[z]DM = days to maturity; plant ht. = plant height; 100-SW = 100-seed weight; n.s. = not significant.

Regional Yield Trials for Chinese Cabbage

Introduction

In cooperation with a number of Taiwan District Agricultural Stations, regional yield trials were conducted to evaluate AVRDC promising Chinese cabbage in major production areas.

Materials and Methods

Three AVRDC promising Chinese cabbage lines were tested against ASVEG No. 1 and one local check in eight locations for the regional yield trials (CCRYT) in summer 1985.

The experiment was conducted in a randomized complete block design with four replications. Plot size was 18 m x 27.3 m. Spacing was 75 cm between rows and at 35 cm between plants within the row.

Results and Discussion

In the summer 1985 trials AVRDC 82-46 and ASVEG No. 1 gave the highest average yields of 38.58 t/ha and 38.49 t/ha, respectively, which were 16% higher than that of the local check, but the differences among all entries were not significant (Table 6).

In the trial, most farmers preferred AVRDC 82-156 because its plant type and head shape are similar to the native cultivar Chang-puh. AVRDC 82-156 also had firmer heads and higher and more uniform yields. Taichung DAIS will submit AVRDC 82-156 to the Seed Committee for name designation and registration in July 1986.

Conclusion

AVRDC 82-156 will be submitted to the Seed Committee for release because of its similarity in plant type and head shape to 'Chang-Puh' and its advantages in yield and head firmness.

Table 6. Yields of entries in the Taiwan Chinese cabbage regional yield trials, summer 1985.

Entry	Yield (t/ha)				Index
	Hualien DAIS (Fenglin)	Tainan DAIS (Tungshis)	Kaohsiung DAIS (Luchu)	Mean	
AVRDC 82-46	34.43 a	41.39 ab	39.93 a	38.58	116
AVRDC 82-156	32.84 a	39.41 ab	38.63 a	36.96	111
AVRDC 82-157	32.08 a	40.86 ab	32.63 b	35.19	106
ASVEG No.1	34.27 a	48.98 a	32.21 b	38.49	116
Nan Tzu No.2	25.96 b	35.00 b	38.65 a	33.20	100
LSD(0.05)[z]	3.986	13.994	4.440	n.s.	
LSD(0.01)[z]	5.589	19.621	6.749	n.s.	

[z]n.s. = not significant.

Regional Yield Trials for Processing Tomato

Introduction

Regional Yield trials were conducted in cooperation with the Tainan District Agriculture Improvement Station to evaluate promising AVRDC lines in Chianan area.

Materials and Methods

Three AVRDC F1 hybrid processing tomato lines were tested against Tainan #2 and TK 70 in three locations in late summer, fall, and winter.

The experiment was conducted in a randomized complete block design with four replications. Plot size was 40.5 m x 33.5 m. Spacing was 1.5 m between rows and at 0.4 m between plants within the row.

Results and Discussion

In the 1984 late summer trial, PT 862 and TM 103 gave the highest average yields of 38.95 t/ha and 38.87 t/ha, respectively which were 79% and 78% higher than that of the local check (Table 7). In the fall trial TM 103 gave the highest yield (75.15 t/ha) which was 15% higher than that of TK 70. In the winter trial TM 103 (90.54 t/ha) was again the best yielder.

In all the three-season trials, TM 103 was the top yielder. Based mainly on yield and fruit appearance, it was included again in the regional yield trials of 1985.

In the 1985 late summer trial, PT 3027 gave the highest yield of 23.52 t/ha, which was higher by about 1,014% than TK 70 (Table 8). All the tested samples were sent to factories for processing. According to the product analysis of President Enterprises Corp., the processing quality of PT 3027 for canned whole tomatoes and sliced tomatoes are acceptable.

Conclusion

Tainan DAIS will submit PT 3027 to the Seed Committee for release in November 1986.

Table 7. Yield and horticultural characters of entries in the Taiwan processing tomato regional yield trials in late summer, autumn, and winter, 1984-85.[z]

Entry	Summer				Autumn				Winter			
	Yield[y] (t/ha)	Index	DM	FS (g)	Yield[y] (t/ha)	Index	DM	FS (g)	Yield[y] (t/ha)	Index	DM	FS (g)
TM 103	38.87 a	178	108.6	69.7	75.15 a	115	112.3	63.7	90.54	122	122.8	86.7
PT 858	35.95 a	165	109.3	84.8	72.41 ab	111	113.3	88.1	84.69	114	120.9	110.7
PT 862	38.95 a	179	106.4	77.6	68.00 abc	104	112.9	74.7	85.87	116	122.0	103.1
TK 70	21.81 b	100	116.0	67.6	65.36 bc	100	115.7	66.7	74.21	100	125.1	100.6
Tainan No.2	21.90 b	101	126.9	76.4	60.05 c	92	118.6	75.6	70.04	94	126.0	100.1
LSD(0.05)	4.43				9.16				n.s.			
LSD(0.01)	n.s.											

[z]DM = days to maturity; FS = fruit size; n.s. = not significant. [y]Yields having the same letter in each column are not significantly different at the 5% level according to Duncan's multiple range test.

Table 8. Yield and horticultural characters of entries in the Taiwan processing tomato regional yield trial, late summer 1985-86.[z]

Entry	Yield[y] (t/ha)	Index	Days to Maturity	Fruit Size (g)	pH	Soluble Solids (°Brix)	Titratable Acidity (%)	Hunter Color (%)
TM 103	15.42 b	731	72	49.9	4.09	5.08	0.413	2.06
PT 1600	12.57 c	595	84	51.4	4.30	5.85	0.358	2.65
PT 3027	23.51 a	1114	72	52.6	4.07	4.82	0.378	2.44
TK 70[x]	2.11 d	100	94	55.7	–	–	–	–
Tainan No. 2[x]	1.58 d	75	94	51.1	–	–	–	–
LSD(0.05)[w]	2.71		–	n.s.				
LSD(0.01)	3.94							

[z]Date sown = 10 July; date transplanted = 6 August; date harvested = 16 October to 7 November 1985. [y]Yields having the same letter in each column are not significantly different at the 5% level according to Duncan's multiple range test. [x]In the first and second harvests no fruits were harvested for quality analysis. [w]n.s. = not significant

Regional Yield Trial for Fresh Market Tomato

Introduction

Regional yield trials were conducted in cooperation with the District Agriculture Improvement Stations (DAIS) and the Taiwan Seed Improvement and Propagation Station (TSIPS) to evaluate AVRDC and TSIPS promising lines in the highland (elevation above sea level 500 to 800 m).

Materials and Methods

Four AVRDC promising tomato lines for the fresh market and four improved lines from TSIPS were tested against TSIPS #1 and cv. Known You 301 in six locations in the summer regional yield trial (FMTRYT) in 1985.

The experiment was conducted in a randomized complete block design with four replications. Plot size was 32 m x 33 m. Spacing was 75 cm between rows and 50 cm within the row.

Results and Discussion

PT 774 gave the best average yield of 49.6 t/ha, which was 18% higher than that of TSIPS No. 1, but fruit color was not uniform, and so, it cannot be accepted by the Taiwan fresh market. Also, bacterial wilt susceptibility was 48% (Table 9).

Conclusion

Since results were not satisfying, AVRDC promising lines will have to be re-evaluated next summer.

Table 9. Yield and horticultural characters of entries in the Taiwan regional yield trial for fresh market tomato in summer 1985.

Entry	Yield (t/ha)								Fruit Shape Index	Fruit Size (g)	Fruit Shoulder Color	Bacterial[z] Wilt (%)
	Shanchung B.S		Puli B.S		Hualien DAIS (Sipao)	TSIPS Hsinsei	Mean	Index				
	Chingshan	Yangmingshan	Yuchi	Hsinyi								
CL 5915-2060-4-2-2-0	33.6 bc	47.5	25.4 b	34.2 ab	69.4	28.1	39.7 abc	95	0.89	105.2	Uniform	29
PT 1722	24.8 de	45.4	22.9 c	31.3 b	69.8	1.5	32.6 bc	78	0.86	142.7	Uniform	83
PT 774	41.6 a	48.8	29.6 a	28.6 b	115.3	33.7	49.6 a	118	0.83	100.6	Uniform	48
PT 778	31.6 bcd	47.5	27.2 b	29.0 b	61.4	26.0	37.2 bc	89	0.84	100.4	Uniform	48
CB 6-1	24.3 de	48.1	22.9 c	38.3 a	61.2	12.9	34.6 bc	83	0.91	114.7	Dk. grn.	45
CB 6-13	22.3 e	46.1	17.8 d	18.8 c	56.5	25.6	31.2 c	75	0.98	121.1	Dk. grn.	19
CB 8-1	30.1 cde	44.9	16.6 d	17.3 c	52.4	28.5	31.6 c	76	0.98	108.7	Dk. grn.	24
TSIPS No. 1	39.1 ab	53.6	30.9 a	32.5 b	68.7	26.8	41.9 abc	100	0.81	135.6	Dk. grn.	18
Known You 301	24.1 de	41.2			65.8		43.7 ab	104	0.91	112.8	Dk. grn.	100
LSD(0.05)[y]	7.45	n.s.	1.96	5.27			10.05					
LSD(0.01)	10.27		2.67	7.18			n.s.					

[z]The Puli B.S. and TSIPS trials were surveyed only. [y]n.s. = not significant.

Regional Yield Trials for Vegetable Soybean

Introduction

With Kaohsiung DAIS and Taichung DAIS, AVRDC conducted regional yield trials in major production areas to evaluate promising AVRDC lines.

Materials and Methods

Six AVRDC promising vegetables soybean lines were tested against two local cultivars, 205 (TzuZu No ku) and Ryokkoh, in six locations in spring and three locations in summer.

The experiment was conducted in a randomized complete block design with five replications. Plot size was 26 m x 34 m. Spacing was 50 cm between rows and at 10 cm between plants within the row.

Results and Discussion

In the 1985 spring trial, AGS 190 gave the highest average total plant yield of 28.89 t/ha, which was 47% higher than cv. 205. For marketable yield AGS 292 was the best yielder in the Kaohsiung DAIS trial (Table 10).

In the 1985 summer trial, AGS 295 and AGS 292 gave the highest average yields of 15.75 t/ha and 15.38 t/ha, respectively, which were 14% and 12% higher than that of the local check. AGS 292 again gave the highest marketable yield in the Kaohsiung DAIS trials.

In the pooled Kaohsiung DAIS and AVRDC trials, AGS 190 gave the best two- and three-pod yields of 6.70 t/ha, but the percentage of qualified pods (pod width = 1.3 cm and pod length = 4.5 cm) was lower. AGS 292 was the second best yielder, the smallest regression coefficient (b = 1.02, r^2 = 0.85), which means that this line is a stable one (Table 11 and Fig. 1).

In the testing and grading trial at the Kaohsiung DAIS, AGS 292 showed a quality similar to cv. 205 (Table 12).

Conclusion

Kaohsiung DAIS will submit AGS 292 to the Seed Committee for release in April 1986.

Table 10. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials in spring and summer, 1985.[z]

Entry	Spring					Summer				
	Yield[y] (t/ha)	Index	MY (t/ha)	MP No. (515 g)	DM	Yield[y] (t/ha)	Index	MY (t/ha)	MP No. (515 g)	DM
AGS 190	28.89 a	147	5.17	221	97	12.96	94	5.67	227	80
AGS 291	20.01 b	102	5.12	141	82	7.55	55	0.97	184	75
AGS 292	21.16 b	108	7.24	154	75	15.38	112	6.35	182	68
AGS 293	19.94 b	101	4.70	156	82	13.93	101	2.94	188	73
AGS 294	20.87 b	106	5.32	160	80	14.23	103	5.16	201	69
AGS 295	19.81 b	101	4.84	157	78	15.75	114	6.29	210	70
205	19.67 b	100	4.92	160	83	13.78	100	5.53	222	74
Ryokkon	21.45 b	109	5.08	157	78	13.83	101	4.00	188	72
LSD (0.05)	3.45					n.s.				

[z]MY = marketable yield in Kaohsiung DAIS; MP no = marketable pod no.; DM = days to maturity; n.s. = not significant. [y]Yields having the same letter in each column are not significantly different at the 5% level

Table 11. Two- and three-pod yields (t/ha) of entries in the Taiwan vegetable soybean regional yield trials in spring and summer, 1985.

Entry	Spring				Summer		Mean
	Hsinpei	Kaohsu	Likang	AVRDC[z]	Chutien	AVRDC[z]	
AGS 190	7.79 a	3.43	6.04	5.95 a	5.84	11.13 a	6.70
AGS 291	4.05 b	4.10	6.78	0.81 e	0.77	6.46 d	3.83
AGS 292	7.87 a	4.04	6.91	3.69 c	4.95	9.84 ab	6.22
AGS 293	3.79 b	4.63	6.02	1.21 de	2.17	8.78 bc	4.43
AGS 294	4.78 b	5.24	6.53	4.89 b	4.26	9.30 bc	5.83
AGS 295	4.50 b	4.02	5.67	1.82 d	4.87	8.15 c	4.84
205	5.39 b	4.90	6.26	3.34 c	4.30	9.56 bc	5.63
Ryokkoh	4.25 b	4.09	6.35	1.50 de	3.12	9.06 bc	4.73
LSD (0.05)[y]	1.56	n.s.	n.s.	0.88	1.24	1.42	
LSD (0.01)	2.13			1.20	1.69	1.93	

[z]Yields having the same letter in each column are not significantly different at the 5% level according to Duncan's multiple range test. [y]n.s. = not significant.

Table 12. Promising vegetable soybean entries according to pod and seed characters and taste, DAIS, 1985.[z]

Entry	Pod		Seed		Taste		Mean
	shape	color	size	firmness	sweetness	tasting	
AGS 291	2.2	2.2	3.1	2.7	3.0	3.2	2.7
AGS 292	3.1	3.5	3.3	3.1	3.1	3.0	3.2
AGS 293	2.1	2.1	2.9	2.6	2.6	2.6	2.5
Yukinoshita	3.5	3.9	3.2	2.9	2.9	3.1	3.3
205	3.3	3.5	2.9	3.2	3.1	3.2	3.2
Ryokkoh	2.4	2.1	3.3	2.2	2.9	2.9	2.6

[z]Rating scores: 4 - Excellent, 3 - Good, 2 - Fair, 1 - Poor. Average of 30 persons tasting.

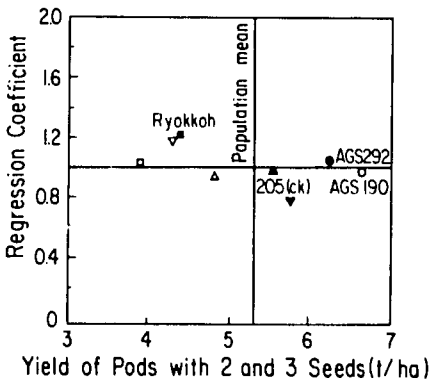

Fig. 1.
The relationship of pod yield (with 2 and 3 seeds) and stability of eight vegetable soybean entries grown at different locations in spring and summer 1985.

Regional Yield Trials for Sweet Potato

Introduction

In cooperation with District Agriculture Improvement Stations (DAIS), AVRDC conducted regional yield trials to evaluate AVRDC promising lines in the Taiwan sweet potato production areas.

Materials and Methods

Five AVRDC promising sweet potato lines were tested against three lines from Chiayi Agriculture Experiment Station in three locations in spring and four locations in summer.

The experiment was conducted in a randomized complete block design with six replications. Plot size was 28 m x 38 m. Spacing was 1 m between rows and at 25 cm between plants within the row.

Results and Discussion

In the spring 1985 trial, CN 1232-9 with an average yield of 28.77 t/ha was considered the best yielder (Table 13). In the summer 1985 trial all tested lines yielded less than the local check TN 66, but the differences among all entries were not significant.

In the two trials pooled together, CN 1232-9 gave the highest average yield of 22.7 t/ha, which was 14% higher than that of TN 66.

In the combined 1984 and 1985 trials, CN 1232-9 had the highest yield with a smallest regression coefficient ($b = 1.09$) and the largest possible coefficient of determination ($r^2 = 0.80$) (Fig. 2). It means that this entry is a stable line.

Conclusion

CN 1232-9 will be included again in the 1986-1987 regional yield trials.

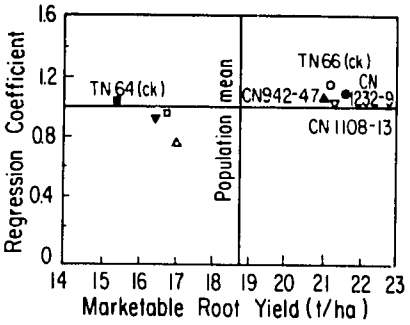

Fig. 2.
The relationship of mean marketable root yield and stability of eight sweet potato entries grown in different locations and seasons, 1984-85.

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AVRDC-Thailand Outreach Program

Chinese Cabbage Varietal Trials, 1982-85

Introduction

From 1982 through 1985, twelve successive varietal trials on Chinese cabbage were conducted at the TOP/AVRDC experimental field at Kamphaeng Saen site of the Kasetsart University. Not all trials had identical and complete sets of varieties, as there were some that differed in variety or in quantity of seeds. In addition, some varieties had poor stands due to low germination rates. The 12 trials covered each month of the year in order to determine Chinese cabbage response to different planting dates (Fig. 1).

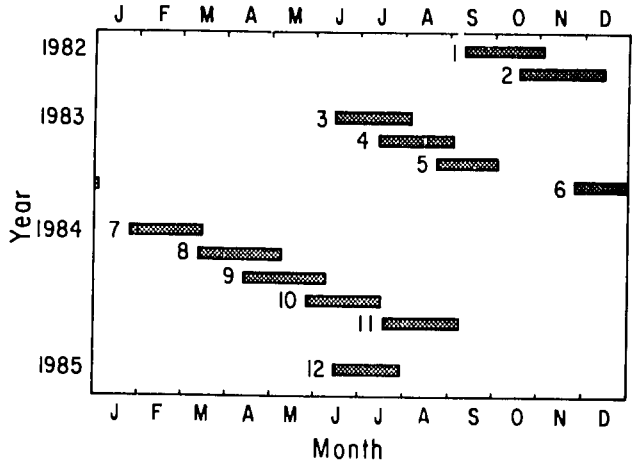

Fig. 1. Chinese cabbage trials of the Thailand Outreach Program/Kamphaeng Saen, 1982-85.

Materials and Methods

The trials comprised 16 hybrids and 15 open-pollinated Chinese cabbage varieties from AVRDC and one or two commercial varieties as checks. Each trial was carried out in a randomized complete block design with three replications. Plot size was 1.5 x 4.8 m, except in the last two trials which consisted of five top-yielding varieties with good horticultural characters. Plot size was doubled and plant population increased to ensure a meaningful yield data.

The Thais prefer Chinese cabbage with a long, cylindrical, hairless head which is not too firm. High-yielding AVRDC varieties which perform well throughout all seasons and possess these characters were chosen for the large-scale trials.

Results and Discussion

The commercial variety Elephant Brand yielded as well as the heat-tolerant varieties from AVRDC, but as soon as the temperature reached 35°C in summer, its yield dropped drastically because of its inability to form head (Table 1). However, this high temperature in the field had little effect on the yielding ability of the heat-tolerant Chinese cabbage varieties.

Five best lines from AVRDC produced yields higher than that of the commercial variety. These lines were Hybrid #80-12, Hybrid #62 Hybrid #8144, 77M(2)-25, and 77M92/3)-46. Hybrid #62 gave the highest average yield, but its head is round and has some leaf hair. As a matter of fact, all these cultivars, except Hybrid #8144, had a rather round head shape. Hybrid #8144, however, was susceptible to soft rot in the field.

Table 1. Average yield (t/ha) of Chinese cabbage in different seasons at TOP/KPS, 1982-1984.[z]

Varieties	Summer (March-June)	Rainy (July-October)	Cool (November-February)
Hyb#80-12	11.4 a	13.1	19.9
Hyb#62	13.4 a	12.9	22.3
77M(2)-25	12.8 a	13.4	17.4
77M(2/3)-46	12.3 a	10.2	18.4
Elephant Br. (Ck)	7.3 b	10.3	18.9
LDS 5%	*	NS[y]	NS[y]

[z]Thailand Outreach Program/Kamphaeng Saen.
[y]NS = not significantly different.

Conclusion

Five heat-tolerant AVRDC Chinese cabbage varieties gave higher yields than the commercial cultivar, especially in the summer season. However, the horticultural characters of these varieties need to be further improved, or the eating habits of the Thai people changed.

Insecticide Control of Diamondback Moth and Cabbage Center Grub

Introduction

Diamondback moth (*Plutella xylostella* L.) and cabbage center grub (*Hellula undalis* F.) are the most serious insect pests on Chinese cabbage and other cruciferous crops in Thailand. This study aimed to determine the insecticides that can effectively control them, and at the same time leave a minimum residue on Chinese cabbage.

Materials and Methods

This was conducted at the TOP/KPS field in 1984. Eight applications of several insecticides were sprayed every five days after transplanting. The number of each kind of larva was counted four times at 30, 40, 50, and 60 days after sowing.

Results and Discussion

Based on the results of this experiment, the following insecticides and their application rates for the control of these two insect pests in Chinese cabbage are recommended:

For the diamondback moth:

1. Teflubenzuron	0.005%
2. *B. thuringiensis*	20 cc/20l liters
3. Triflumuron	0.0375%

For the cabbage center grub:

1. Teflubenzuron	0.005%
2. Triflumuron	0.0375%
3. KIC	0.1%

Varietal Trial on Grain Soybean

Introduction

Several high-yielding AVRDC lines from previous studies were tested at TOP/Kamphaeng Saen in 1984-85.

Materials and Methods

A randomized complete block design with four replications was used for this trial. Plot size occupied eight rows 5 m long with a spacing of 50 cm between rows and 8 cm between plants.

Results and Discussion

Local check cultivar SJ.5 gave the highest yield of 1.9 t/ha, but it was infected by downy mildew (Table 2.) AGS 154, AGS 129, and AGS 58 had lower yields than the check cultivar; however, they were all resistant to downy mildew. The unusual drought which occurred at flowering stage is believed to have contributed to the low yield and short stems of soybean plants obtained from this trial.

Table 2. Yield and other agronomic characters of SJ. 5 and AVRDC lines at Thailand Outreach Program/Kamphaeng Saen, 1984-85.

Lines	Yield (t/ha)	Plant Height (cm)	Days to Maturity (days)	100-seed Wt (g)	Downy Mildew Score[z]
AGS 58	1.66	35.1	81	17.7	0
AGS 129	1.66	46.3	81	14.0	0
AGS 154	1.85	69 6	81	10.4	0
SJ.5 (Ck)	1.90	54.2	81	15.0	2

[z]Score based on disease incidence: 0 = none to 5 = serious.

Conclusion

Although the local check gave the highest yield, it was vulnerable to downy mildew.

Varietal Observation on Vegetable Soybean

Vegetable soybean has not been popularized nor has any special variety been selected to be grown in Thailand. Thai farmers usually harvest the green pods of the grain-type soybean and use them

as vegetable soybean. Last year, we received only a token amount of vegetable soybean seeds from AVRDC. They were planted without replication in our field for observation purposes. Some agronomic data of these soybean lines were collected throughout the growing season and are listed in Table 3.

Table 3. Some characteristics of the AVRDC vegetable soybeans observed in the 1985 growing season at Thailand Outreach Program/Kamphaeng Saen field.

Soybean Varieties	Pod Yield (t/ha)	Days to Harvest	Plant Height (cm)	No. of Pods/kg
G 3213	13.9	74	30.9	312
G 2057	13.8	62	33.9	441
G 5487	12.8	68	32.4	378
G 7856	11.9	74	39.1	378
G 6421	11.1	68	49.4	472
G 7321	11.0	74	37.1	350
G 6466	10.6	74	34.3	388
G 5463	9.9	74	27.4	454
G 6318	6.8	74	27.6	425
G 6852	5.9	74	27.7	360
G 10134	5.3	74	36.6	255

Mungbean Varietal Trials

Seventeen experimental trials to determine mungbean yield and other horticultural characters were conducted from 1982 to 1984 in Thailand with 9 cultivars and 11 breeding lines from AVRDC. These trials were conducted not only at the TOP/KPS field, but also at Suwan Farm (Thailand National Corn and Sorghum Research Center) and other research stations in Thailand.

AVRDC mungbean varieties, VC 1973-A and VC 2778-A, were found to be the most stable and high-yielding lines with some better agronomical characters than the current Thai national cultivar, Uthong #1 which is highly susceptible both to Cercospora leaf spot (CLS) and powdery mildew (PM) (Table 4). Its canopy is too big and it lodges easily. VC 1973-A and VC 2778-A demonstrated higher resistance to both CLS and PM. They have the same seed type and seed weight as Uthong #1, but they have a smaller canopy with the pod clustered up high to facilitate harvesting.

Table 4. Agronomic characteristics of mungbean cultivars VC 1973-A and VC 2778-A as compared with the Thai national cultivar Uthong #1.

Traits	No. of Trials	VC 1973-A	VC 2778-A	Uthong 1 (Ck)
Yield (kg/ha)	17	1246.0	1130.0	936.0
100-seed wt (g)	16	66.3	65.8	65.3
Disease response[z]				
Leaf spot	7	2.7	2.3	3.2
Powdery mildew	3	2.9	1.8	4.4

[z]Disease score: 1 = resistant to 5 = susceptible.

The Thai Department of Agricultural Extension has also been testing those two lines against Uthong #1 in the farmers' fields since 1984. Both of these AVRDC mungbean lines are preferred to Uthong 31 by the Thai farmers, and the demand for their seeds is high.

New VC 1973-A and VC 2778-A seeds were released by the government and private agencies to farmers under the names of cvs. Kamphaeng Saen 1 and Kamphaeng Saen 2, respectively.

Sweet Potato Germplasm Collection

One of the biggest sweet potato germplasm collections in Thailand is maintained at TOP/KPS fields. There are 48 sweet potato lines with 40 lines obtained from AVRDC, two lines from China, and six lines from Thailand. These lines were apportioned to other research institutes, such as Pakchong Research Station and Khon Kaen University in the Northeast part of Thailand, for research and storing in order to ensure their future survival.

Sweet Potato Yield Trial

Introduction

Sweet potato varietal trials were conducted at TOP/KPS from 1982 to 1984.

Materials and Methods

A randomized complete block design with three replications, four to six rows/plot, and 12 plants/row was adopted in these varietal trials. Each trial used 'Ungbuay' as local check cultivar.

Results and Discussion

Higher yields were obtained in the dry season than in the rainy season where only a few or no roots at all were formed because of excessive soil moisture. The AVRDC sweet potato lines gave better yields than the local check cultivar, but their root texture and other characters varied much (Table 5). Research on sweet potato products for use as animal feed, starch, etc. has not been initiated in Thailand.

Table 5. Sweet potato yield (t/ha) obtained from trials at AVRDC-Thailand Outreach Program/Kamphaen Saen.

Lines	1983	1984
CN 1219-1	–	19.0
CN 1028-15	17.3	18.7
PC #9	22.6	18.5
AIS 0122-2	21.2	13.7
Ungbuay (Ck)	12.4	13.4

Conclusion

AVRDC sweet potato cultivars outyielded the local checks.

Effect of Plant Density on Sweet Potato Yield

Introduction

Plant population is one of the factors that affect the yield of sweet potato. The best spacing for this crop is still being researched.

Materials and Methods

Spacing between rows was constant at 75 cm, but varies within rows at 15, 30, 40, and 60 cm.

Results and Discussion

Sweet potato cultivar AIS 0122-2 responded to different plant densities. At 75 x 15 cm root size, top weight, and yield per plant decreased, but total root yield and number of roots per plant increased. The optimum plant density which gave the maximum root yield (17.2 t/ha) and an acceptable root size (70 g) was 75 x 30 cm.

Conclusion

Optimum plant density was at a spacing of 75 x 30 cm.

Evaluation of Heat-Tolerant Tomato Varieties

Small-fruited tomato varieties which are tolerant to heat and resistant to bacterial wilt were tested in all seasons at the TOP/KPS fields from 1983 through 1984.

All CL 1104 lines showed poor adaptability to KPS conditions and gave lower yields than some lines of CL 1131. From the trials of all seasons, CL 143-0-10-3-0-1-10 had the highest average marketable yield which was somewhat better than that of SVRDC 4. SVRDC 4 was adopted in different parts of Thailand as the best fruit-setting variety.

Thais are used to noncracking tomatoes with small fruit size, pink color, ovate to pear shape, and little firmness. The long-preferred local tomato cultivar Seeda possesses all these Thai marketable qualities which the AVRDC heat tolerant tomatoes do not have.

Performance Trials of Table and Processing Tomatoes

New AVRDC tomato breeding lines, CL 5915-136D4-1-0, CL 5915-233D4-3-1-0, CL 5915-371D4-1-2-0, and CL 5915-206D4-2-4-0 with some degree of heat tolerance and bigger fruit size were tested during the off-season, while the maximum and minimum temperatures at fruit-setting period was 33.0° and 23.7°C, respectively.

The AVRDC heat-tolerant tomato lines are both determinate and indeterminate types. Their fruit weights ranged between 31 to 78 g which were higher than those of the local checks Seeda (22 g) and SVRDC 4 (23 g). All varieties, except Seeda (7 t/ha) and CL 5915-206D4-2-4-0 (9.8 t/ha) had higher yields ranging from 17.2 t/ha (SVRDC 4) to 14.2 t/ha.

Both CL 5915-136D4-1-0 and CL 5915-223D4-3-1-0 are new breeding determinate tomato which gave better yield and fruit size than heat-tolerant cultivar SVRDC 4 and check cultivar Seeda.

Trial on F1 Hybrid Processing Tomato

In 1984, a number of PT lines and F1 hybrid tomatoes for processing were tested three times at the TOP/KPS field. Lines PT 862, PT 867, PT 897, PT 912, PT 913, PT 1017, and TM 103 produced higher yields in all seasons than VF 134-1-2 which supplies the largest amount of processing tomato for factory use in Thailand.

Tomatoes for processing are usually grown in 1,300 to 2,200 ha in the north and northeast of Thailand during October to December. Average yield is about 15 t/ha. The length of the tomato growing period is limited by temperature and the availability of heat-sensitive tomato varieties. The production period might be extended to at least three to four months with tomatoes that carry some degree of heat tolerance.

The early-season trial of processing tomato was conducted at TOP/KPS field from September to December 1985 when the night temperature at fruit setting was higher than 23°C. PT 1017 (12.2 t/ha) and TM 103 (10 t/ha) gave much better yields over the check VF 134-1-2 (1 t/ha). Although these two lines performed better in yield, their fruit qualities have yet to be tested further.

TM 103 might be planted in early or late season to reduce the risk of poor setting due to high temperature during season-turning period.

Weed Control

The major problem in tomato production is costly hand weeding and, so, several herbicides were studied. Results showed that metribuzin 0.5 kg (a.i.)/ha still proved to be the best pre- and post-emergence herbicide for tomato. The serious weed species found in the TOP fields were *Thianthema portulacastrum*, *Amaranthus spinosus* and *Echinochloa colonum*.

Fertilizer Rate and Application for Tomato

In TOP fields, the soil is sandy and silty loam with poor organic matter. The optimum rate and time of fertilizer application for tomato are recommended below:

Days after Transplanting	Kind of Fertilizer	Rate (kg/ha)
basal	15-15-15	200
7	21-0-0	375
25-30	15-15-15	200
50	21-0-0	200

Effect of Plant Density on Tomato Yield

Different spacings between plants and a fixed spacing between rows were used (Table 6). Yields between Tainan Sel. #2 and Seeda were significantly different from each other. Yields gradually increased with closer spacings and was highest at the spacing between plants of 100 x 30 cm. Fruit weight was not significantly different among treatments.

Table 6. Effect of plant spacing on number of fruits per plant, fruit weight, and yield of Tainan Sel. #2 and Seeda tomatoes.

Spacing between		No. of Fruits/Plant		Fruit Wt		Yield (t/ha)	
Rows	Plants	Seeda	TN Sel. #2	Seeda	TN Sel. #2	Seeda	TN Sel. #2
100	30	26.3	14.3	18.7	71	17.5	33.5
100	40	26.2	17.5	20.3	69	14.4	29.8
100	50	29.9	18.1	20.6	76	13.0	27.3
100	60	37.4	21.1	20.1	73	12.9	25.6
100	75	34.9	17.8	19.5	78	9.3	18.3
LSD .05		NS	NS	NS	NS	3.4	5.78

[z]NS = not significantly different.

Effect of Staking and Mulching on Tomato Yield

Introduction

To increase yield is a major objective of any crop-improvement program. This may be achieved not only through breeding aimed at improving crop yield, but also through research to develop improved cultivation methods. One way to increase marketable tomato yield is by reducing fruit rot.

Materials and Methods

Staking and secondary rice-straw mulching were conducted in the rainy season by using SVRDC 4 cultivars which are soft and small in fruit size.

Results and Discussion

Application of a secondary rice straw mulch at 40 days after transplanting was found the most effective method of reducing fruit rot (Table 7). Shorter harvesting intervals (two harvestings every six days) also produced better yields. Staking tomatoes with bamboo sticks 20 days after transplanting kept the tomato plants from the ground and resulted in significantly higher yields than the tomatoes without support.

Table 7. Effect of staking and mulching on yield and fruit rot of tomato cultivar SVRDC at AVRDC-Thailand Outreach Program/Kamphaen Saen.[z]

Cultivation Method	Harvest Interval (days)	Marketable Yield (t/ha)	Fruit Rot (%)
Staking	6	42.2 b	25.5 a
	3	45.5 a	13.8 b
Mulching	6	35.2 c	22.6 ab
	3	37.9 bc	12.2 b
Control	6	31.7 c	26.0 a
	3	38.3 bc	18.5 ab

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Conclusion

Mulching, staking, and shorter harvest intervals resulted in better tomato yield.

Breeding for Heat Tolerance in Processing Tomato

A tomato-improvement program had been started since 1983 to introduce heat tolerance to the local processing tomatoes by crossing. The limiting factors for generation advance at Kamphaeng Saen are the prevalence of severe tomato yellow leaf curl and high night temperatures of over 24°C in summer time. As a result, few or no seed set in the summer season was observed.

A few tomato seeds of processing tomatoes resistant to yellow leaf curl were obtained from AVRDC and crossed with the heat-tolerant tomato varieties. The degree of heat tolerance in the second and third generations was still better than that of the local processing tomato, and desirable characters will be selected in the following generation.

Home Garden

With a small home garden, the family can obtain daily fresh vegetables without worrying about toxic pesticide residues. Good physical exercise for health can also be achieved through garden work. Although cash is not the primary purpose of the home garden, this often results to supplement the family income.

At TOP fields in Kanphaeng Saen, several kinds of vegetables were grown on a demonstration home garden 5 x 5 sq m in area. Each kind of vegetable was grown on a bed 1 to 2 m^2.

The garden should be able to provide vegetables for a family of four to five persons at least five days a week. They need to work only less than one hour a day to take care of the growing vegetables.

The vegetables which can be obtained at different growing periods of the year in Kamphaeng Saen are green onion, coriander, celery, kale, pakchoi, kang kong, Chinese cabbage, leaf mustard, lettuce, amaranthus, spinach, bitter gourd, and yard-long bean.

Regional Program

Regional Training

In February 1985, we completed the 3rd AVRDC Regional Training Course for Vegetable Production and Research with 17 training scholars who graduated. The 4th Regional Training Course at Kamphaeng Saen, Thailand was conducted from October 1985 to February 1986. There were nine training scholars in this session.

Lengthy and complicated government procedures of the candidates' own countries, not the financial sponsorship, often caused delay and the eventual failure of many potential training candidates to attend the training course. The basic content of our training course is similar to that of the training conducted at AVRDC, except that we do not have all the necessary qualified staff and facilities as AVRDC at present.

With the efficient coordination of Mr. D. V. Castro and the able and enthusiastic support of the scientists from AVRDC, Thailand, and other international institutions, our regional training course has been very successful. They were praised by present and past participants and their respective governments and sponsors. This can be reflected in the training reports and activities as depicted in the slides.

4/11

Genetic Resources and Seed Unit

Status of AVRDC Germplasm

Germplasm Introduction

In 1985, 390 soybean accessions were introduced from eight countries (Table 1). The newly acquired accessions included 52 breeding lines which will be evaluated by the breeding group in the 1986 spring season. One accession from India with photoperiodic insensitivity is noteworthy for breeding cultivars with a wider range of adaption.

Twenty-three mungbean introductions were received from four countries. Among them, seven were duplicates of our germplasm and seven were mixed samples. After sorting out the mixed samples there were altogether 24 new introductions (Table 1). In addition, one rice bean (*Vigna umbellata*) from India was received. For the *Brassica* species, 45 new introductions were obtained from six countries, and 24 of which were already accessioned. A total of 560 new tomato introductions were also received.

Table 1. New germplasm introductions at AVRDC, 1985.

Source	No. of Entry	Remarks
Soybean[z]		
Brazil	58	52 breeding lines
India	28	1 photoperiod-insensitive
Indonesia	98	
Philippines	80	
USA	92	
Vietnam	29	
Zambia	4	
Zimbabwe	1	
Subtotal	390	
Mungbean[y]		
India	2	Also one rice bean
India	15	Seven are duplicates of our collection
Iran	4	One introduction is a three-seeded type
Philippines	2	
Thailand	1	
Subtotal	24	
Brassica[x]		
Japan	12	Accessioned; OP; subsp. *rapa*
Japan	2	" ; OP; subsp. *chinensis*
Korea	4	" ; F1; subsp. *pekinensis*
Mauritius	3	" ; OP; subsp. *pekinensis*

Table 1. Continued.

Source	No. of Entry	Remarks
Mauritius	2	Accessioned; OP; *B. juncea*
Taiwan, China	1	" ; F1; subsp. *pekinensis*
Australia	2	Temporary number;OP; subsp. *chinensis*
Rep. of Korea	5	" ;F1; subsp. *pekinensis*
China	14	" ;F1; subsp. *pekinensis*
Subtotal	45	
Tomato		
Colombia	90	*L. esculentum* and var. *cerasiforme*
USA (Ohio)	1	For TMV genes
Mexico (thru. Spain)	98	—
Peru (thru. California)	37	*L. pennellii* (for CMV genes)
Mixed sources	238	Breeder's working collection
Mixed sources	28	Breeder's working collection (wild species)
Mixed sources	68	Breeder's working collection (F1 and other early generations)
Subtotal	560	
Total	1019	

[z]All entries are still temporarily numbered. [y]There were 23 original entries; 24, after sorting. [x]OP = open-pollinated.

The entire germplasm collection maintained by the AVRDC Genetic Resources and Seed Unit is summarized in Table 2. The current status of the germplasm characterization for 1985 is summarized in Table 3.

Seed Distribution

We continued to provide germplasm materials to scientists at AVRDC and elsewhere, to provide plant quarantine service, and to ship seeds and plant materials to various countries (Table 4). Of the 16,209 samples shipped out, most were breeding lines for international testing. The total samples of other crops sent out increased to 1,376 from 449 in 1984.

Seed Distribution Survey

Introduction

Annually, we distribute about 20,000 seed samples to about a hundred countries, costing us about US$9,000 on shipment procedures alone (including parcel air mail postage and documentation). If we include the cost of seed production, storage and packaging, it will add up to a considerable sum, making distribution an expensive activity. However, this is an important step in our overall program to get our materials tested in target areas and provide us with the necessary feedback for assessing progress.

Unfortunately, only about 46.71% of the acknowledgment cards enclosed with every seed package are returned yearly. Hence, it is difficult to ascertain the status of 53.29% of the shipments. In order to improve our services and decrease cost, a seed distribution survey was conducted to evaluate our packaging system and to understand more about our cooperators' quarantine requirements.

Materials and Methods

A questionnaire consisting of 13 questions was prepared in consultation with our scientists and approved by the Director General. The questionnaires were sent out in the next seed shipment packages. The target was to obtain at least two responses from each country. To date, a total of 264 questionnaires were sent to 94 countries.

Table 2. Germplasm maintained by AVRDC's GRSU in 1985.

Crop	Accessions	Missing[z]	Available	Temporarily Numbered Accessions	Suspected Duplicates[y]
AVRDC Principal Crops					
soybean	12,244	838	11,406	390	2,111 (9,034)
mungbean	5,282	165	5,117	24	985 (5,112)
tomato	5,366	138	5,228	560	40 (4,734)
sweet potato	1,200	32	1,168	0	9 (1,200)
Chinese cabbage	846	42	804	21	–
Subtotal	24,938	1,215	23,723	995	3,145 (20,089)
Other Crops					
adzukibean	125				
amaranth	86				
black gram	158				
rice bean	72				
Subtotal	441				
Total	25,379				

[z]342 missing accessions were replaced in 1985. [y]Figures in parentheses indicate the total number of accessions from which the suspected duplicates were counted.

Table 3. Status of germplasm characterization in 1985.

Crop	Status
Tomato	A total of 4,708 accessions completed with nine characters; other accessions and characters to be added.
Sweet potato	Above-ground vegetative and root characters completed; flower characters completed for those that flowered; will confirm again in the coming season.
Chinese cabbage	Out of the 376 OP and suspected OP accessions, 315 characterized on vegetative characters and 121 on flower and fruit characters.
Mungbean	Whole collection completed with 35 characters and partially done on four characters.
Soybean	Non-USDA accessions (2,672 accessions) Completed.
Black gram	Completed.

Results and Discussion

Out of the 264 questionnaires sent out, 91 responses were received from 57 countries. This represented returns of 34.47%.

A seed packet may take up to 150 days to arrive at its destination. It may take another 150 days of poor storage before the seeds are planted. The suggestions already implemented to improve our packaging and services are as follows:

1. Introduction of two stickers with notices like 'Seeds for Experimental Purposes (No Commercial Value)','Phytosanitary Certificate Enclosed', etc.
2. Introduction of a warning note to return the acknowledgment card
3. Closer checking of seed materials and packaging by the GRSU pathology assistant before inspection by the local Quarantine Officer
4. Providing seed treatments

Table 4. External seed distribution in 1985 (germplasm and breeding lines).

Country	Seed Packets		Total
	5 AVRDC crops	other crops	
Thailand	3,242	53	3,295
Philippines	1,362	112	1,474
Indonesia	1,023	95	1,118
Pakistan	1,027	2	1,029
USA	985	21	1,006
Rep. of Korea	806	75	881
India	789	49	838
Malaysia	527	188	715
Taiwan, China	382	86	468
Bangladesh	357	5	362
Others[2]	4,333	690	5,023
Total (95)	14,833	1,376	16,209

[2]Includes 85 countries and territories: Anguilla Islands, Antigua, Argentina, Australia, Austria, Barbados, Belgium, Belize, Bhutan, Bolivia, Botswana, Brazil, Brunei, Burkino Fasso, Burma, Canada, Chile, Colombia, Cook Islands, Costa Rica, Cuba, Dominican Rep., Ecuador, Egypt, El Salvador, England, Espana, Ethiopia, Fiji Islands, France, Gambia, Germany, Ghana, Guadeloupe, Guiana (French), Guyana, Haiti, Holland, Honduras, Hong Kong, Hungary, Iran, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, Liberia, Malawi, Maldives, Mauritius, Mexico, Nepal, Nicaragua, Nigeria, Paraguay, Peru, Reunion, Samoa (W), Saudi Arabia, Seychelles, Sierra Leone, Singapore, Solomon Islands, South Africa, Sri Lanka, St. Kitts, St. Lucia, Sudan, Sweden, Tahiti, Tanzania, Togo, Tonga, Trinidad & Tobago, Turkey, Venezuela, Virgin Islands, Yemen, Yugoslavia, Zaire, Zambia and Zimbabwe.

The following are recommendations to improve our packaging and services:

1. Use Al-PE pouches or high-density PE bags instead of paper bags for the legume crops because of delay in shipment and planting and poor storage conditions.
2. Label the pouches/bags clearly in good handwriting.
3. Send packing list in advance to alert the recipient about shipment.
4. Aim for inspection of seed production fields by the local quarantine office.
5. Enclose in seed packets or publish in 'Centerpoint' a list of new advanced lines released for testing.

Conclusion

On the whole, our seed distribution system was considered satisfactory. On several occasions we were being complimented. However, from the few constructive comments by the respondents we were able to introduce new ideas to strengthen our shipment program and to set up new objectives for further improvement.

Chinese Cabbage Seed Production for Long-Term Storage (AVRDC-IBPGR Joint Project)

Introduction

The letter of agreement , 3/11 IBPGR Crucifers December 7, 1982, covers the period from January 1985 to December 1986. Its objective is to continue seed multiplication and characterization until all the open-pollinated materials are deposited in the cruciferous base store at the National Vegetable Research Station (NVRS) in Wellesbourne, United Kingdom and the National Institute of Agrobiological Resources (NIAR) in Tsukuba, Japan.

Materials and Methods

Seed production was done in insect-proof field cages each 12 m x 4.2 m in size. Each cage was planted with about 200 to 250 plants of an accession. Because of natural variations (since they were all open-pollinated cultivars) bolting was frequently not uniform even after vernalization. The vernalization period ranged from 15 to 70 days, depending on the source of origin of the individual accessions.

If responses to vernalization were not good, long-day photoperiodic treatments were given during the seedling or vegetative stages in the field. In the 1984-85 season, we started long-day treatment on some of the unevenly bolting accessions, and the result was very promising. We aimed at a representative random seed lot from at least 100 plants/accession. This was achieved by subsampling an average of 2.5 g/plant from all the plants in an accession. The plants were harvested individually.

Results and Discussion

In the 1984-85 season 81 accessions were planted, and 50 accessions with more than 100 plants/accession were sent to NVRS. Twenty-nine accessions which have less than the required number of plants during multiplication are now temporarily kept in AVRDC's long-term store until seeds from more plants are being produced in the 1985-86 season. This happened because the original seed stocks of the twenty accessions were very few; and to avoid complete loss in case of field disaster in a single planting, we divided each accession into two halves to be planted in two seasons.

One-half was planted in the 1984-85 season, and the other for the 1985-86 season. Because of the warm weather in the 1984-85 winter and possibly of the inaccurate vernalization period, eleven accessions did not bolt well. This season, we used a longer vernalization period and light treatment to induce bolting for these accessions. The germination rate of the seeds produced in the 1984-85 season averaged 9.88%. The varietal purity of the seeds produced was good. Only five accessions were found to have some amount of contamination.

The total number of accessions sent to NVRS so far was 264 accessions. In addition, a set of 251 accessions was also sent to the National Institute of Agrobiological Resources (NIAR), Tsukuba, since they are responsible for storing the duplicate base collection of *Brassica campestris*.

Conclusion

At the end of phases I, II, and III a total of 121 accessions remains to be sent to NVRS.

Chinese Cabbage Descriptor List and Characterization (AVRDC-IBPGR Joint Project)

Introduction

Brassica campestris is a polymorphic species. It is grown for its root, stem, leaf, head, flower, and seed. Classical taxonomy has divided it into seven subspecies as follows: *campestris*, *pekinensis*, *chinensis*, *parachinensis*, *narinosa*, *rapa*, and *japonica*. Therefore, any descriptor list formulated has to accommodate these vast variations, otherwise, several lists have to be developed for the different taxa.

The objectives of this project are 1) to propose a comprehensive descriptor list of *Brassica campestris* (including all the subspecies/cultivar groups) for the International Board for Plant Genetic Resources (IBPGR); 2) to test the proposed descriptor list and to study the relationship between the characters; and 3) to produce a catalog for the Chinese cabbage collection.

Materials and Methods

The proposed descriptor list used the two IBPGR (1981 and 1982) descriptor lists for cruciferous crops as working examples, and to put them together into a more comprehensive one. In addition,

other useful characters have to be added. The draft list should then be tested in the field on different groups of *B. campestris* materials in order to delete or to modify some of the less useful and not so well-described characters. Each character state should be well defined. Field characterization will then be easier and more accurate because there will be less problems on deciding which descriptor state to record for each particular case.

Finally, the tentative draft will be presented to the Chinese cabbage scientists for review before the descriptor list will be finalized.

Results and Discussion

Descriptor list. The proposed descriptor list has a total of 122 characters. They are divided into three sections according to the IBPGR standard format. The different characters in each section which also provides a comparison between the two previous descriptors and the present proposed one. The morphological and physiological characters can be divided into three main types of attributes - nominal, numeric, ordinal.

In nominal attributes, no meaning was assigned to the order of the individual character states. The different discrete states were numbered for operational convenience. Frequently, figures were included to show the different character states. In case of numeric characters, direct measurements were done on at least five randomly selected individuals from each accession. Ordinal attributes were orderly coded with number to quantify the situation. We adapted the 0-9 scale with the three major states at 3, 5, and 7 for low, intermediate and high, respectively. When a character was totally absent zero was assigned.

Characterization. Because of diverse ecological subgroups within a subspecies (e.g., the heat-sensitive and heat-tolerant heading Chinese cabbage) we had to split them into winter or summer planting groups during characterization even though the number of accessions per group was small. A further complication is that planting for the marketable part usually does not produce flowers. On the other hand, once the plants bolted they lost their vegetative identity.

Normally, we had to resolve to at least two plantings. For the heat-tolerant heading form and the leafy forms mostly from the sub-tropical and tropical regions, the vegetative parts were characterized in the summer and the reproductive parts in the winter. As for the heat-sensitive forms, both plantings were in winter except that one set had to be vernalized to induce flowering. So far, 315 of the OPs have been characterized for vegetative characters, and 121 for reproductive characters.

The total number of morphological and agronomic characters is 72; and in order to facilitate the use of the list, it was divided into two parts: 1) characterization and preliminary evaluation and 2) further characterization and evaluation. Based on its usefulness and ease in recording, a character was assigned to either one. The Chinese cabbage collection is usually small (only 322 OP's at AVRDC) and, therefore, more detailed data can be taken. The following are some of its different characters.

Seedling, mature plant, and head characters. A number of characters are compared between the heat-sensitive and heat-tolerant types of heading Chinese cabbage in Table 5. Out of the ten characters only the number of leaves and leaf width showed no significant differences between the two groups. A comparison between their coefficients of variation indicated that the heat- sensitive materials were more variable because of the presence of different cultivar groups. There are only two major cultivar types in heat-tolerant Chinese cabbage: those from Southern China and Thailand.

The correlation between the characters were generally low except for cotyledon length and width, and total weight and head weight. There was some correlation between leaf length and leaf width in the heat-tolerant type because the majority belongs to the Southern Chinese group. Within the heat-tolerant type there were also higher correlations between total weight and head length, and head weight and head length.

Flower and pod characters. The two measured flower characters are petal length and width. The means of the petal length and width were 11.31 and 6.48 mm, respectively. Correlation between petal length and width was 0.702 indicating a size factor involved.

The four pod characters measured were silique length and width, beak length, and number of seeds per pod. The means of silique length, silique width, beak length, and number of seeds/pod were 4.05 ± 0.66 cm, 0.53 ± 0.075 cm, 1.18 ± 0.36 cm, and 21.9 ± 4 seeds per pod, respectively. Other

than the better association between silique length and beak length (r=0.601, p=0.05) correlation between these four characters were poor.

Conclusion.

The above analyses were carried out to provide a preview on the nature of the data and an idea on how the different characters relate to each other. A complete multivariate analysis will be done when the data are complete.

Table 5. Comparison of characters and coefficients of variation between heat-sensitive and heat-tolerant heading Chinese cabbage.

Character	Mean		t Value[/]	Coef. of Variation	
	heat-s	heat-t		heat-s	heat-t
Cotyledon length	17.72	11.95	11.84 **	15.40	8.66
Cotyledon width	21.46	15.66	10.99 **	14.05	6.13
No. of leaves	15.34	14.10	0.98 n.s.	44.56	24.28
Leaf length	39.59	21.91	16.11 **	14.29	10.99
Leaf width	26.31	27.65	-1.66 n s.	13.63	12.21
Midrib width	6.95	4.00	20.50 **	12.19	7.17
Total plant weight	2,407.00	725.00	17.74 **	23.94	16.92
Head weight	1,279.00	432.90	13.34 **	27.89	21.94
Head length	27.17	12.16	15.05 **	20.80	7.56
Head width	15.61	9.11	11.01 **	20.96	10.23

[/]Significant level at the 0.01 level = **. No significant difference at the 0.05 level = n.s.

Characterization of the World Mungbean Collection

Introduction

The letter of agreement, PR 3/11 IBPGR Information, dated 14 October 1983 covers the project period from February 1985 to January 1986. Its objective is to characterize mungbean according to the IBPGR descriptor list for *Vigna radiata* (AGP: IBPGR 80/35), and to conserve the world mungbean collection.

There are 5,282 accessions from 49 countries in the mungbean collection. Since about 50% of these accessions have different types of seeds within an accession, they were sorted out in 1984 into individual types according to seed characteristics; namely, luster, color, size, and shape. A total of 7,965 entries was obtained after sorting.

Materials and Methods

The second half of the whole collection consisting of 4,714 entries from accessions V 2650 to V 6111 were planted in two blocks on 17 September 1985, and 3 October 1985. Each entry was planted in double rows on a plot, 1 x 2 m. Two-meter plots were used in order to produce enough seed for stock and for chemical analysis by the Near-IR analyser. About two to three weeks after sowing, thinning was done to a single plant per hill every 5 cm within the row. The AVRDC standard crop-management practices were followed. There was no pest and disease problem. Virus-infested plants were rogued when there were less than ten plants in a plot. Harvesting commenced on 13 November.

Big sets of accessions were characterized together in order to remove some of the environmental G x E effects of season on the unreplicated plots. In addition, a character was assessed by the same team throughout to avoid any variation in definition by different individuals.

Results and Discussion

Characterization was completed on 35 characters and partially done on four characters. Two new characters i.e., leaf size and seed starch, were added. A summary on mungbean characterization including the 1984 results is shown in Table 6.

Table 6. Summary of mungbean characterization in 1984 and 1985.

Character	IBPGR Descriptor Code	Planting Season[z] 1984	1984	1985
Growth habit	3.1	S		
Hypocotyl color	3.3	S	F	F
Leaf: (1) terminal leaflet shape	3.4.1	S		
(2) pubescence - number	3.4.3	S		
(3) color	3.4.4			F^x
(4) petiole color	3.4.5	S		
Raceme position	3.5.3		F	F
Flower: (1) calyx color	3.5.4	S		
(2) corolla color - standard	3.5.5	S		
Pods: (1) pod color	3.6.1		F	F
(2) pod pubescence - number	3.6.7	S^x	F	F
(3) pod length[y]	3.6.6	S	F^y	F^y
Seeds: (1) color	3.7.1	S^x	F	F
(2) mottling on seed	3.7.2		F	F
(3) surface luster	3.7.3	S^x	F	F
Flower: (1) days to flowering	4.3	S	F	F
(2) plant height when flowering[y]	4.5	S	F^y	F^y
Flowering period	4.9		F^x	
Number of clusters[y]	4.11		F^y	F^y
Maturity, days	4.12	S	F	F
Lodging	4.14		F	F
Pods per plant	7.1		F^y	F^y
Seeds per pod[y]	7.2	S	F	F
1000-seed weight	7.3		F	F
Seed protein	11.1		F	F
Primary leaf: length[y]	Addition	S	F	F
width[y]	Addition	S		
shape	Addition	S		
Leaf: (1) pubescence length	Addition	S		
(2) vein color	Addition	S^x		
Flower: corolla color - wings	Addition	S		
Pod pubescence: color	Addition	S^x	F	F
length	Addition	S^x	F	F
Seeds: hilum color	Addition		F	F
Plant height at maturity[y]	Addition	S	F^y	F^y
Seed starch	Addition		F	F
Seed fiber	Addition		F	F
Leaf size	Addition			F
Number of characters studied per season	24 (1984S)	24 (1984F)	25 (1985F)	
Total no. of recordings taken per season	313,000 (1984S)	160,000 (1984F)	231,000 (1985F)	

[z]Planting season: 1984S - spring season (March to June), 7,640 entries from V 1001 to V 6112. 1984F - fall season (August to December), 3,400 entries from V 1001 to V 2649. 1985F - fall season (September to December), 4,714 entries from V 2650 to V 6111. [y]Five readings were recorded per accession. S^x or F^x - partially characterized in summer or fall.

Conservation of the World Mungbean Collection

AVRDC is designated to keep the base collection of mungbean in the IBPGR international network of gene banks. One main problem of this collection is the highly polymorphic seed types within an accession which has about 15 seed morphotypes. Reports from 1984 indicated that 50% of the accessions have more than one type of seeds per accession. The reason for this is not clear.

Mechanical mixtures have to be sorted out and breeding mixtures conserved as in a single population or isolated if out-pollination is high. Experiments were carried out to find out the causes. The results may provide us with sufficient information to formulate a strategy on multiplication of mungbean for long-term storage.

1. Causes of Differing Mungbean Seed Morphotypes

Introduction

Mungbean is basically a self-pollinating species. Pollination occurs before the flower is completely opened. Out-pollination was reported to be low. However, field observations showed several species of insects, usually bees and blowflies, on mungbean flowers. At AVRDC, the whole mungbean collection is outside its home environments. This may somehow cause the breakdown of the built-in self-pollinating mechanisms of this legume, thus, increasing the chances of out-pollination by visiting insects. By isolating insects and plants in cages we may be able to study the importance of out-pollination in mungbean at AVRDC.

Materials and Methods

Selected for this study were 160 entries from 62 accessions with more than one seed type per accession. One set of the 160 entries was planted in a 1-m double-row plot per entry inside an insect-proof nylon cage, and another set was similarly planted outside on 28 March 1985. Standard AVRDC management practices were used.

Bad weather during the flowering and harvesting stages completely damaged several plots. These entries were, therefore, excluded from the study. The seeds of those that were harvested were cleaned and sorted out into the different seed types within each accession.

Results and Discussion

Out of the 160 entries inside the cage, 28 were completely destroyed in the bad weather. From the remaining 132, only 31 entries bred true to their original types and the rest segregated into two to six seed-types. The two-seed types were 42.4% of the total.

Outside the cage, 46 entries out of the 160 were destroyed by the bad weather. The trend of segregation was similar to that found inside the cage, with 34 entries breeding true to types and 42 entries segregating to two-type seeds. One entry, V 4950, which is dull in surface texture and mosaic green in color, segregated into dull mosaic black seeds, dull green seeds, dull brown seeds, shiny green seeds, shiny mosaic green seeds, and shiny mosaic black seeds, in addition to the original type.

The trends in segregation between plants inside and outside the cage were not significantly different ($x^2 = 4.0010$, $p = 0.30\text{-}0.50$). Of the 100 segregates of the same entries inside and outside the cage, 53% gave similar seed types. Another 32% had one or two extra types in both places of what otherwise would have had similar segregation types.

Conclusion

Segregation patterns for seed types were similar for entries in both inside and outside the cage. This indicates that segregation due to past cross-pollination and/or expressivity of genes may both

be the cause. The harvested seeds will be planted again to test whether out-pollination took place outside the cage in 1985.

2. Competition among Different Genotypes

Introduction

Competition between morpho-ecotypes is a common phenomenon. The dominant type will slowly take over. With our mungbean accessions, competition may be even more serious because the original population was moved from its home habitat to a new environment at AVRDC. Seed lots from 1976 and 1982 in our medium-term store were examined and compared for possible changes in seed types. The results of this survey indicated unfavorable changes.

However, these changes may also be due to different seed viabilities between types during storage. In order to conserve genes we have to take all possible precautions to prevent losses due to different seed storability and field competition. This experiment was carried out to study the competition between different morpho-genotypes.

Materials and Methods

The materials used and their characteristics are as follows:

	Origin	Ratio
1. V 1062 (shiny, green) vs. V 1062 (shiny, brown)	Hong Kong	1:1
2. V 1251 (shiny, green) vs. V 1251 (dull, green)	India	1:1
3. V 1428 (shiny, yellow) vs. V 1428 (dull, green)	Philippines	1:1
4. V 1686 (dull, green) vs. V 1686 (dull, brown)	Afghanistan	1:1
5. V 4946 (dull, green) vs. V 4946 (shiny, green)	"	1:1
6. V 1006 (dull, black) vs. V 1242 (shiny, green)	Thailand, Afghan.	1:1
7. V 1024 (dull, yellow) vs. V 4947 (dull, mosaic black)	" "	1:1
8. V 1240 (shiny, mosaic black) vs. V 2492 (dull, green)	Afghan., Afghan.	1:1
9. V 1714 (shiny, green) vs. V 1026 (shiny, yellow)	Iran, Thailand	1:1
10. V 2590 (shiny, mosaic black) vs. V 1241 (shiny, green)	India, Afghanistan	1:1
11. VC 1000-D (dull, green) vs. V 1240 (shiny, mosaic black)	AVRDC, Afghan.	1:1
12. VC 1177-A (dull, yellow) vs. V 1241 (shiny, green)	" "	1:1
13. VC 1177-B (shiny, yellow) vs. V 1240 (shiny, mosaic black)	" "	1:1
14. VC 1560-D (shiny, green) vs. V 1024 (dull, yellow)	AVRDC, Thailand	1:1
15. VC 2768-A (shiny, green) vs. V 1024 (dull, yellow)	" "	1:1

Groups 1 to 5 were selected to compare competition between similar morphotypes. Each group was derived from the same accession but with different seed characteristics. Diverse origins of the five accessions were chosen in order to include the different ecotypes.

Groups 6 to 10 consisted of comparisons between different morpho-physiotypes from different accessions with different seed characteristics. Group 6 was V 1006, black gram, *Vigna mungo*, vs. V 1242, mungbeans with similar plant heights. Group 7 was between two late-flowering types. Group 8 was between a tall type with a plant height of 43-cm at flowering, and a short type with a 21-cm height. Group 9 was similar to group 8. Group 10 was between two almost similar types.

Groups 11 to 15 consisted of comparisons between two vigorous AVRDC advanced breeding lines well adapted to AVRDC environment, and three more vigorous accessions.

The two types within each group were mixed thoroughly in a ratio of 1:1 by weight, and then divided into four subsamples for the four replicates before planting.

The experiment was planted on 3 May 1985 in a randomized complete block design with four replicates. Plot size was a double-row bed of 4 m. Spacing and crop management were done according to standard AVRDC recommendations. The whole plot was harvested and the ratio by weight of the

two types was determined. The use of only two seed types in each group allowed this to be done accurately.

Results and Discussion

Because of wet weather in June, July, and August (rainfall totalling 998 mm), the average yield was 185.6 g per plot. Seed quality was poor and good seed averaged only 55.48%. An analysis of variance indicated no significant difference in block effect. Group 5 was completely destroyed in the four replicates. The yields of groups 1, 7, 14, and 15 were low (an average of 41.97 g/plot).

After one planting, groups 6, 7, 13, 14, and 15 were reduced to only one-seed type. In groups 8, 9, 10, and 11, one of the types was drastically reduced to an average of 6.27% only. Other than group 5 which was destroyed, the single-accession groups were more stable as suspected because competition was not as severe as between two completely different morpho-physiotypes.

An analysis (using χ^2 heterogeneity test) of results of the remaining groups, i.e., groups 1, 2, 3, 4, and 12 showed that groups 1, 3, 4, and 12 already deviated from the initial 1:1 mixture. Only group 2 was a more stable mixture.

Conclusion

Out of the fourteen mixtures (group 5 was completely destroyed in the wet weather) only group 2 remained stable. The others either lost one type or had one type significantly reduced to a lower level. For genetic conservation, we have to be aware of this and take all possible precautions to prevent this from happening. The number of regenerations of an accession should be cut down by keeping seeds in the base collection.

Since about 50% of the collection consists of different seed mixtures we have to decide whether to conserve them as mixtures in each accession or to sort them out into single type and conserve them individually. Individually sorted seeds will still segregate into other types. Proper precautions during regeneration should then be taken to avoid out-crossing.

Experiment II indicated severe competition between different morphotypes/genotypes but not as seriously between closely related morphotypes. From field characterization of individual seed types, morpho-physiotype differences within an accession can be identified. If the differences between the morpho- physiological types within an accession are small the different types will be conserved as a single population. If the differences are great the individual types will be conserved separately to prevent competition.

Chemical Analysis of Mungbean Seeds

Introduction

Mungbean is an important nutritious pulse which has a high and easily digestible protein. Its starch is also used in making noodles. The fiber in mungbean is mostly found in the seed coat which may affect its cooking quality. Chemical analysis of the collection will reveal the variations in the constituents of each accession. This will provide the mungbean scientists with reference information.

Materials and Methods

Seeds of 3,373 entries from the 1984 autumn crop were sent to the Chemistry Department for analysis on protein, starch, and fiber with a Near-IR analyser.

Results and Discussion

The accuracy of the Near-IR analyser was evaluated by doing 25 determinations from 25 subsamples of an accession. The coefficient of variations and range differences of each item were small. The

protein portion was divided into two types, protein 1 and protein 2, determined on different wavelengths. Correlation between them was high (r=0.979) and, therefore, only protein 1 was analysed statistically below.

The distributions of protein, starch, and fiber, expressed in percentage of fresh weight, are shown in Fig. 1. Comparison between these values and that published in the "Food Composition Table for Use in East Asia (FAO)"[†] indicates no serious discrepancy.

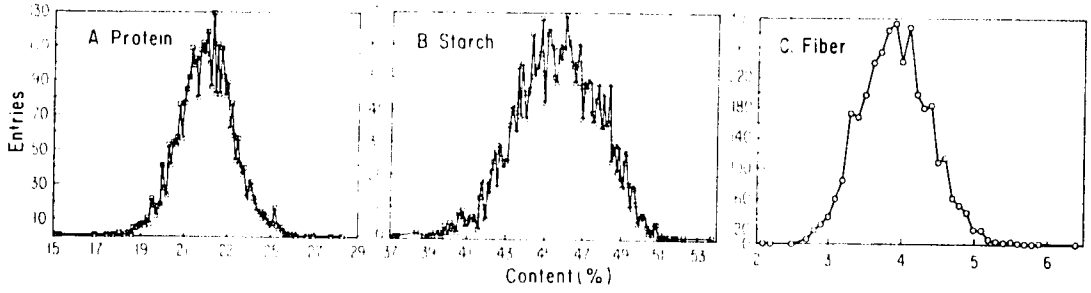

Fig. 1. Food content distribution in the mungbean germplasm collection.

Protein. The accession with the highest protein-1 content was V 5020 from Australia (30.07%). The next four accessions were V 1523 (Canada), V 1516 (Pakistan), V 1173 (India), and V 1517 (Salawesi) with 28.30%, 27.78%, 26.97% and 26.71%, respectively. The source of high protein therefore is probably diverse. The first six accessions have a dull seed texture and, except for V 1173, they all have a yellow seed coat. The top one-hundred accessions with high protein 1 were counted for yellow and dull seed coat independently and then compared with the population ratio for yellow vs. other colors and dull vs. shiny texture. They were both significantly different from the population ratio and at a more frequent levels, indicating that protein might be linked with yellow and dull seed coat. There was no significant relationship between protein and mottled (mosaic) seed coat. Green-coated mungbean had significantly less protein ($x^2=23.77$, $P\times0.005$). Further studies have to be done to confirm this finding.

The accessions with protein 1 greater than 25%, wet weight basis, (read from left to right in descending order) are: (* - mosaic)

V 5020B-Y	V 1523B-Y	V 1516B-Y	V 1173B-G	V 1517B-Y
V 1024B-Y	V 5068A-G	V 2017B-BL*	V 2615A-G	V 1359B-G
V 1143B-BL	V 2433A-G	V 3054B-BR	V 4898B-BL*	V 1495A-G
V 1033B-G	V 2091B-BL	V 2218B-G	V 2237A-G	V 2089A-BL
V 5021A-G*	V 2128B-BL	V 1768A-G	V 1967A-G	V 1215A-G
V 1513B-Y	V 1633B-G	V 2153B-Y	V 2135B-BL	V 4911B-Y
V 1211A-G	V 5028A-G	V 4900A-BL*	V 1117B-G	V 2485B-BR
V 2509A-G	V 1440B-G	V 2510A-G	V 2192B-G	V 1662A-G
V 2245B-G	V 1086A-Y	V 5076B-BR	V 2118B-BL	V 1017B-G
V 1683A-G	V 1961B-G	V 1652B-G	V 2260A-G	V 2567B-G
V 4901B-BL*	V 2089A-BR	V 2181A-Y	V 1241B-G	V 1998A-G
V 1236B-G	V 2848B-G	V 1071B-Y	V 1712B-G	V 1755B-BL
V 1755B-G	V 1967B-G	V 1073B-G	V 2137B-BL	V 5082B-G

Starch. The accession with the highest starch content was V 2322 from the Philippines with 54.15%, wet weight basis. The top ten accessions with high starch content had lower protein and fiber compared to the population averages, except for V 2053 with an above-average protein content and V 2281 with an above-average fiber. Analysis indicated that high-starch accessions may be associated with a green and shiny seed coat. This result runs counter to that of protein where high protein accessions tended to have a yellow and dull seed coat. This is reflected in the negative correlation

[†]Food Policy and Nutrition Division, Food and Agriculture Organization of the United Nations.

between protein and starch level in an accession (r=-0.43).

The accessions with starch content greater than 50%, wet weight basis, (read from left to right in descending order) are: (* = mosaic)

V 2322A-G	V 2534B-G	V 2281A-G	V 2632A-G	V 2323A-G
V 2331B-G	V 2053B-G	V 2276A-G	V 1913A-G	V 5032A-G*
V 2622B-G*	V 1942A-G	V 1823A-G	V 2885A-G	V 2324B-G
V 2423A-G	V 1872A-G	V 1833B-G	V 2592A-G	V 1888B-G
V 1937A-G	V 5002A-G	V 5023A-G	V 1867A-G	V 2535A-G
V 2279A-G	V 2323B-G	V 2482A-G	V 2780A-G	V 1928A-G
V 1984A-G	V 1926A-G*	V 2540A-G	V 3184B-G	V 1809B-G
V 2883A-G	V 2605A-G	V 2363A-G	V 1970A-G	V 1914B-G
V 5032A-G	V 2031B-G	V 2229A-G	V 2862B-G	V 1965B-G
V 2253A-G	V 1819B-G	V 2292A-G	V 3474A-G	V 1830B-G
V 2276B-G	V 2525A-G	V 1837B-G	V 2144A-G	V 2331A-G
V 3889A-G	V 5018A-G	V 1953B-G	V 2633A-G	V 2272A-G
V 3182A-G				

Fiber. Mungbean is relatively low in fiber. The accession with the highest fiber content was V 1373 from France (6.4% wet weight basis). It had an above-average protein content (23.72%) and a green, shiny seed coat. Among the top ten high-fiber accessions were seven with above-average protein levels.

However, the correlation between protein and fiber in the collection was low and negative (r=-0.212); six of them had black seed coats both dull and shiny in texture.

Analysis on X^2 indicated that high-fiber accessions mostly had black seed coat, some of which are motiled. The surface texture probably had nothing to do with high fiber. Among the top 25 high-fiber accessions; 14 were black gram, *Vigna mungo*. This indicated that black gram had higher fiber than mungbean. V 1160, *Vigna glabrescens* also had high fiber (5.79%) but below-average protein and starch contents.

The correlation between fiber and starch was -0.497.

Conclusion

Protein in mungbean can be as high as 30.07%, wet weight basis. High protein is postulated to be associated with a dull and yellow seed coat. Starch in mungbean can be up to 54.15%, wet weight basis. It may be associated with a green, shiny seed coat. Fiber in mungbean is low. Black gram has a higher fiber content than mungbean.

The correlation between protein and starch contents and between protein and fiber contents are low and negative. Between starch and fiber it was -0.497.

Flower Induction in V 1160, *Vigna glabrescens*

Introduction

A description of V 1160 reported in 1984 was confirmed by Professor R. J. Marechal of Belgium to be *Vigna glabrescens*. It is a potential source of resistance to pests, diseases, and weeds; however, it is highly photoperiod-sensitive (responding only to short days) and does not flower in spring at AVRDC.

The 1984 research showed that the treatments (day lengths shortened by 30 to 150 min) did hasten flowering even at a 30 min shorter day length. Since the experiment was carried out in autumn, a time of normally shortening day length, we repeated the study in spring 1985, with an increasing day length.

Materials and Methods

The treatments selected were 1) decreasing day length, the same as from 16 September; 2) decreasing day length, the same as from 10 October; 3) decreasing day length, the same as from 25 October; 4) constant 11-h day length; 5) constant 12-h day length; 6) constant 13-h day length; and 7) check.

The experiment was planted on 11 April 1985. Each treatment consisted of 12 plants in four 20-cm pots with three plants per pot. Black plastic-sheet covers simulated darkness. Treatments were initiated on 13 May, 43 days after sowing.

Results and Discussion

The first flowering occurred 67 days after sowing in treatment 3, i.e., decreasing day length at AVRDC from October 25. It was followed by treatment 4, i.e., constant 11-h day length 68 days after sowing. The flowering times were still not comparable to the regular flowering period of mungbean planted in spring at AVRDC (around 43 days after sowing). This may be due to the slow initial growth of V 1160. At 76 days after sowing, both treatments 2 and 5 flowered at the same time. Treatment 6 and the check did not flower even up to 130 days after sowing. This indicates that short-day treatments have to be less than 13 hours to induce flowering in *V. glabrescens*.

Both the first flowering time and the total number of flowers are shown in Table 7. The flowering patterns for the different treatments are summarized graphically in Fig. 2 with the cubic curve fitting*. From the areas subtended by the cubic curves and Table 7, the first three treatments indicated higher average number of flowers per plant than the constant short day-length treatments (treatments 4 and 5). One factor causing lower flower number in treatment 4 was probably the heat which might have affected general growth of the plants under the black plastic sheet from 3:54 P.M

Table 7. First flowering day and total number of flowers per plant with different day-length treatments.

Treatment	First Flowering (days after sowing)	Mean Number of Flowers per Plant
1	81	145.8
2	76	213.6
3	67	196.8
4	68	125.1
5	76	144.9
6	0	0
7	0	0

However, if we compare treatments 3 and 5, the former gave a higher average number of flowers per plant. This may indicate that decreasing day-length treatments may have certain advantage over constant day-length treatments. In addition, Fig. 2 indicates a double-peak distribution in flowering (observe the scatter points instead of the curve). The first peak was between 76 and 92 days after sowing. This distribution was probably the result of first and second flushes of flowering in mungbean.

Conclusion

Vigna glabrescens, V 1160, can be induced to flower both by using decreasing day length from 13 day length down or by using a controlled short day length of less than 13. The former appeared to be better.

*As in 1984, the cubic curve fitting was found more suitable for this type of data. This is reflected by a decrease in residual sum of squares from quadratic to cubic equation.

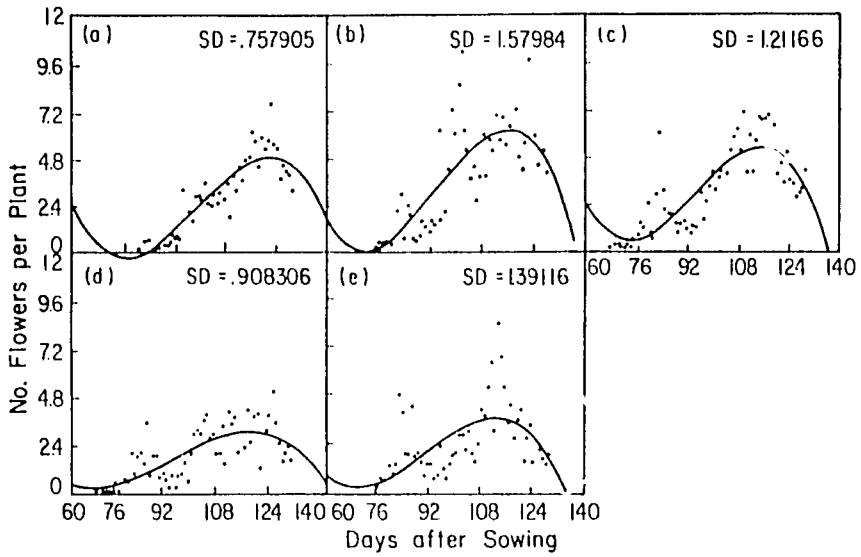

Fig. 2. Flowering patterns for (a) treatment 1 - decreasing day length as from September 16; (b) treatment 2 - decreasing day length as from October 25; (d) constant 11-h day length and (e) constant 12-h day length.

Monitoring the Viability of Seeds in Cold Storage

It is important to check the progress in deterioration of a seed lot. In genetic resources conservation, the threshold for regeneration is set well before the rapid dying stage because before that mutations start to occur. As deterioration progresses mutations accumulate and may eventually become fatal and irreversible. The threshold value at the AVRDC genebank is set at 85% germination rate or a drop of 5% on the initial germination for regeneration. For practical and economic reasons, the monitoring of seed lot is scheduled at five-year intervals.

1. Viability of Chinese Cabbage Seeds in Medium-Term Storage

Introduction

Chinese cabbage accessions in the medium-term store are not systematically kept. An accession consists of seed lots from different regeneration years. This, therefore, takes up valuable cold storage space and creates difficulty in stock inventory. With the present new facilities, steps are being taken to clean and rearrange the store. In the Chinese cabbage collection with 846 accessions, there are now 1,760 seed lots from 11 years of regeneration. This study was, therefore, conducted to determine their viability. A survey was first carried out to understand seed viability in Chinese cabbage.

Materials and Methods

Four accessions, B 2, B 26, B 142, and B 155, were selected because seed lots were available from four different periods: 1) original seed stocks imported in 1972 and 1973; 2) breeders' collection first handled by GRSU in 1975; 3) regenerated seeds from 1976 and 1977; and 4) regenerated seeds from 1981, 1982, and 1983. Germination tests were done according to the rules of the International Seed Testing Association (ISTA) with 400 seeds per seed lot.

Results and Discussion

Germination was good even for the 1975 seed lots. It indicates that if seeds are properly produced, conditioned, and stored in a medium-term store at 2° to 5°C and 40 to 45% RH, viability can be maintained at a high level comparable to new seeds even after ten years of storage. Storage at -20°C will prolong the storage period still further.

The age and quality of the original seed stocks were unknown and, therefore, should not be treated as a drop in germination after the seeds were stored for 12 years.

Conclusion

Chinese cabbage seeds can be stored in medium-term store for more than ten years without any critical loss in germination.

2. Initial Germination Rate of Newly Generated Chinese Cabbage Accessions before Storage

Introduction

The initial germination of every seed lot entering the cold store has to be determined so that subsequent germination rates can be compared. Recently in gene banks, most of these data are computerized in the cold store inventory data base. We plan to do this in 1986.

Materials and Methods

Germination of each seed lot regenerated in 1984 and 1985 was determined according to ISTA rules. Four hundred seeds were used for each determination.

Results and Discussion

The germination rates were very high in both seasons, indicating good quality seed lots. Results from the previous experiment (Experiment I) showed that Chinese cabbage seeds kept in medium-term store at 2° to 5°C and 40 to 45% RH did not show any serious loss in viability even after ten years.

Conclusion

At the present storage condition, at -20°C, with properly dried and packaged seeds, storing for a period of more than twenty years seems possible. However, we still have to monitor the viability every five years.

3. Viability of Soybean Seeds in Storage

Introduction

Soybean is bulky to store in a gene bank because of its large seed size (7 to 30 g/100 seeds). At AVRDC, much cold store space was taken up by duplicate samples of soybean, sometimes in big bulks of up to a few kilograms for distribution. Some of them were stocked since 1974, and so, it is urgent to clear the unviable ones out. Germination tests were done to decide on the seed lots to keep.

Materials and Methods

Soybean accessions in the short-term store were tested for viability according to International Seed Testing Association (ISTA) rules.

Results and Discussion

Altogether 83,200 seeds from 208 seed lots were tested. Seed lots from 1978 germinated better than those of 1979. This led us to suspect that the 1978 seeds were probably kept in medium-term store for a certain period before finally being moved into short-term store. Another set of germination tests was done on seeds stored in five plastic drums about 50 cm in diameter by 80 cm high (Table 8). Drums 1 to 4 were kept most of the time in medium-term store, except for a few months in the short-term store at the beginning of 1983. Drum 5 was always in short-term store.

Table 8. Germination of soybean kept in medium-term and short-term storage.

Container	Year Regenerated	No. Seed Lots	Germination (%) 0	1-50	51-90	91-100	Remarks
Drum 1	1978	3	–	–	–	3(96.17)	[a]Kept in medium-term
	1979	2	–	–	1(62.75)	1(99.50)	store and a few months
	1980	6	–	–	–	6(98.88	in short-term store in 1983.
Drum 2	1978	4	–	–	–	4(97.63)	"
Drum 3	1979	5	1	2(42.38)	–	2(99.00)	"
	1980	9	–	1(06.75)	1(54.00)	7(97.39)	"
Drum 4	1979	2	–	1(24.25)	–	1(97.00)	"
Drum 5	1975	2	2	–	–	–	Kept in short-term store
	1977	3	–	2(34.00)	1(68.75)	–	all the time
	Unknown	7	7	–	–	–	
Total		43	10	6	3	24	

[a]Mean germination rate within the category.

Conclusion

Seed viability of soybean can be maintained well for at least eight years if kept in medium-term storage at 2° to 5°C and 40 to 45% RH. Ordinary window-type air conditioning (20° to 25°C, 55 to 65% RH) is not suitable for storing soybean. A total of 180 kg of nonviable or poor seeds were discarded from short-term storage.

Effect of Pod Development Stages on Seed Storability of Chinese Cabbage

Introduction

Open-pollinated Chinese cabbage usually has different bolting periods within a cultivar. In addition, inflorescence often goes on for two months. This nonuniformity in both stages contributes to a seed crop with different stages of pod development ranging from green to mature brown. Harvesting has to be done continuously according to the development stage of the pods, that is, when the pods change from green to slightly greenish yellow and the seeds are brown or black. Harvesting late when the pods are already brown and dry results in losses due to shattering.

The experiment studied the effect of harvesting at different stages of pod development on seed quality and storability.

Materials and Methods

Four open-pollinated Chinese cabbage accessions, B 469, B 473, B 824, and B 827 were randomly selected from the 1984-85 seed production season for this study. The cages were insect-proof. Pollination, by honey bees of B 469, B 473, B 824, and B 827 was initiated on 17 February for 47 days, 26 January for 50 days, 24 February for 24 days, and 26 February for 24 days, respectively. The pods were harvested forty days after pollination. The four stages of pod development used in this study were:

Treatment 1 - dried pods easily shattered
Treatment 2 - greenish yellow pods with brownish/blackened seeds
Treatment 3 - green pods with hardened green seed turning brown
Treatment 4 - green pods with soft green seeds

Standard germination tests using 400 seeds/treatment were done according to the rules of the International Seed Testing Association (ISTA) on normal and aged seeds. The seeds underwent the accelerated ageing test by Baskin (1981)* in a precision incubator set at 40°C (a seven-day period).

Results and Discussion

The results are presented in Fig. 3. A combined analysis, using the angular transformed data, of seeds before and after ageing indicated highly significant differences ($p \times 0.0001$ except for A x V x P, $p=0.003$) between ageing and nonageing, between accessions, between harvesting stages, and all the interactions among the three factors. Ageing affected the germination rates greatly. Average germination after ageing dropped from the initial 96.62% to 55.38%.

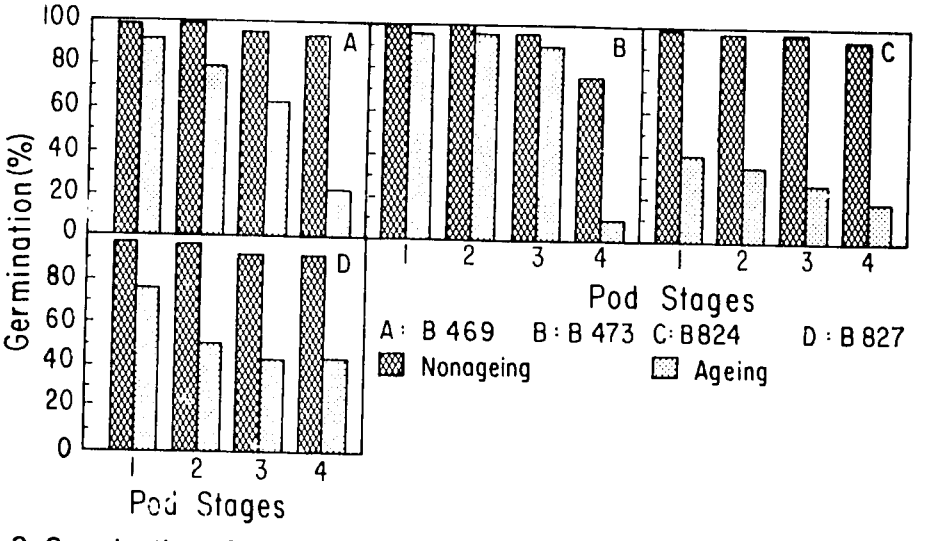

Fig. 3. Germination of four Chinese cabbage accessions harvested at four pod development stages (treatment 1, treatment 2, treatment 3, and treatment 4) before and after ageing.

It seemed that ageing affected B 824 more than B 827, and B 827 more than B 469; B 473 was least affected. Seeds harvested when pods were dried were least affected by the ageing treatment (mean germination rate=76.13%). Green pods with soft seeds were affected the worst (germination rate=23.88%). Since ageing is a way to test seed storability, it is important to harvest the Chinese cabbage seed crop while the pods are turning greenish yellow and the seeds inside are already brown.

Since ageing affected germination drastically, it was decided to analyse the germination data separately before and after ageing, in order to study the interaction between accessions and pod

*Baskin, C.C. 1981. Accelerated Aging Test. In: D.A. Perry (ed) Handbook of Vigour Test Methods. International Seed Testing Association. Zurich, Switzerland.

development stage. A separate analysis of the two sets of germination data showed highly significant differences between accessions, between harvesting stages, and between these two factors.

There was no consistent drop in seed viability when the pods were harvested green as compared with treatments 3 and 2. Treatment 2 is the current harvesting criteria in our seed production fields. However after ageing, the germination patterns of the four accessions at different harvesting stages were different. Germination in B 469 declined uniformly from 92% in treatment 1 to 22.75% in treatment 4. B 473 did not show any significant drop except in stage 4. The quality of the treatment 4 seeds of B 473 was initially not as good as the others. B 824 showed a drop to 40.75% after ageing, even for treatment 1 seeds which were supposed to produce the best seeds in general.

The drop in seed quality when harvested at the green pod stage (treatments 3 and 4) were reflected in smaller seed sizes. The seed size decreased significantly from treatment 1 to treatment 4 at 1.614 mm to 0.956 mm in diameter. In this case, the poor seeds can be separated by a suitable screen. B 827 had the largest seeds (average 1.447 mm diameter).

The lower initial seed viability of B 473 harvested at treatment 4 is also indicated by the small seed size. This was possibly due to harvesting seeds at the very green stage.

Conclusion

Pod ripening varies in open-pollinated Chinese cabbage cultivars because of differences in bolting time and length of the flowering period. Harvesting is done when the pod color turns greenish yellow. This experiment (using only four accessions) showed that harvesting at this stage may not lower seed storability as when harvesting is done when the pods are dry (assessed by the ageing method).

Harvesting when the pods are green will affect seed storability. The decrease in seed storability was reflected by the decrease in seed size as harvesting proceeded from treatment 1 to treatment 4. Losses result when harvesting dried pods because of shattering. It is, therefore, recommended that harvesting be done when the pods are greenish yellow. The smaller (poor) seeds can be removed by a suitable screen.

Survey of Crop Management Practices in Tomato Seed Production

Introduction

In cases where fruit yield is high little is known about the agronomic factors and their interaction with genotype that enhance seed yield. There are no studies on the relationship between seed yield and crop management, except recent ones on parthenocarpic varieties.

A seed production of Tainan Selection No.2 showed good fruit-set but only a few seeds were found in the fruits. It was postulated to be due to the cold night temperature. This study was therefore initiated to survey some of the possible agronomic factors that may contribute to seed yield.

Materials and Methods

Tomato fruits were collected by plot from four experiments for seed extraction. Seed extraction was done plot by plot with a mechanical seed extractor. The seeds were cleaned of mucilaginous materials and dried to 8% moisture content before weighing. Appropriate statistical analyses were done according to the experimental design on seed weight in grams and seed conversion percentage (SC%), i.e., seed weight divided by fruit weight x 100%. The four experiments used were as follows:

1. Title: Maximum yield trial on autumn tomato (Soil Science Department)
   Objective: To test the potential yield of new hybrid cultivars
   Experimental design: Split-split plot with two replicates
   Treatments: Main plot: (1) No compost added
   (2) Compost added (30 t/ha)

Subplot: (1) No deep plowing
(2) Deep plowing
Sub-subplot: (1) TM 103
(2) PT 858
(3) PT 862

Plot size: 4.5 × 5 m

2. Title: Autumn tomato trial after second rice cultivation (Soil Science Department)
Objectives: (1) To know the effect of rice cultivation on soil structure relevant to succeeding tomato crop
(2) To know the effect of plastic sheet mulching on tomato yield
Experimental design: Split-split plot with two replicates
Treatments: Main plot: (1) No mulching
(2) Plastic sheet mulching
Subplot: (1) TM 103
(2) PT 858
(3) PT 862
Sub-subplot:

(1)	Basal	60 N	90 P_2O_5	60 K_2O
	Top (a)	48 N	24 P_2O_5	36 K_2O
	Top (b)	48 N	24 P_2O_5	36 K_2O
(2)	Basal	60 N	80 P_2O_5	60 K_2O
	Top (a)	60 N	0	60 K_2O
	Top (b)	60 N	0	60 K_2O

Top (a) - at three weeks after transplanting
Top (b) - at six weeks after transplanting

Plot size: 4.5 × 5 m, three rows

3. Title: Effect of soil amendment on tomato yield (Soil Science Department)
Objectives: (1) To know the effect of decreased soil pH and of peat application on tomato yield
(2) To know the effect of sulphur application on an increase in available Ca.
Experiment design: Split plot with two replicates
Treatments: Main plot: (1) Peat
(2) Sulphur
(3) Check
Subplot: (1) TM 103
(2) PT 858
(3) PT 862
(4) TK 70

Plot size: 3.5 × 7.5 m

4. Title: Effect of spacing on growth and yield of tomato (Crop Management Department)
Objective: To determine the best spacing for transplanted tomato
Experimental design: Split-split plot with two replicates
Treatments: Main plot: (1) Tainan #2
(2) TM 103
(3) PT 862
Subplot: (1) 1.0 m interrow spacing
(2) 1.2 m interrow spacing
(3) 1.5 m interrow spacing
Sub-subplot: (1) 0.3 m intrarow spacing
(2) 0.4 m intrarow spacing
(3) 0.5 m intrarow spacing

Plot size: 4 × 4 m, 4.8 × 6 m, 6 × 6 m (four beds/plot)

Results and Discussion

Analyses on seed yield and seed conversion percentage were done separately on the four harvests and the total. The results are summarized in Tables 9 to 12. In general, seed yields of the first and fourth harvests were more variable as expected because of the intrinsic differences among the cultivars in fruiting behavior (Table 13). Coefficient of variation up to 5.12% was recorded for experiment 4, harvest 4. SC% occurred only in the first harvest. The total harvest had the least variation. More weight should, therefore, be given to the analyses of the total harvest in the interpretation of results.

Table 9. Seed weight and seed conversion percentage of autumn tomato on the maximum yield trial.[z]

Source of Variation	Harvest 1		Harvest 2		Harvest 3		Harvest 4		Total	
	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)
Compost (Comp)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Deep plowing (Dp)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Comp x Dp	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Cultivar (C)	*	n.s.	n.s.	**	**	***	*	***	**	***
Comp x C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.
Dp x C	n.s.	n.s.	**	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
Comp x Dp x C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mean	61.6	0.345	129.8	0.345	418.1	0.489	143.3	0.418	752.8	0.426
CV	16.4	24.1	8.8	11.2	7.0	4.5	25.0	8.0	5.7	4.6
% of total harvest	8.2		17.2		55.5		19.0			

Duncan's multiple range test at the 5% level

	Seed Weight (g)				Seed Conversion Ratio (SCR)		
Harvest 1 cultivar	TM 103	PT 858	PT 862	Harvest 2 cultivar	TM 103	PT 858	PT 862
	68.1 a	64.1 ab	52.6 b		0.344 b	0.303 b	0.390 a
Harvest 2 cultivar	TM 103	PT 858	PT 862	Harvest 3 cultivar	TM 103	PT 858	PT 862
	137.0 a	120.5 b	133.8 ab		0.425 c	0.478 b	0.563 a
Harvest 3 cultivar	TM 103	PT 858	PT 862	Harvest 4 cultivar	TM 103	PT 858	PT 862
	388.3 b	402.4 b	463.6 a		0.361 b	0.393 b	0.499 a
Harvest 4 cultivar	TM 103	PT 858	PT 862	Total cultivar	TM 103	PT 858	PT 862
	122.3 b	126.4 b	181.2 a		0.376 c	0.406 b	0.495 a
Total cultivar	TM 103	PT 858	PT 862				
	715.7 b	713.4 b	829.3 a				

[z]sw = seed weight; sc% = seed conversion ratio minus; n.s. = no significance; * = significant at the 5% level; ** = significant at the 1% level.

Throughout the four experiments, cultivar differences were highly significant. It was, therefore, the most important determinant of seed yield and SC%. However, from the breeding and agronomic viewpoints, they have little weight on decisions to select and adapt a cultivar. In fact, cultivars with less seeds per fruit may be preferred, in general. On the contrary, the cultivar with low SC% may be undesirable from the seed producer's point of view because of the high cost to produce a unit amount of seed.

An example is Tainan Selection No. 2, which was released in Taiwan and adapted by the tomato-processing industry but which had low seed yield. In experiment 4, it gave only 27.6% of the average of TM 103 and PT 862 in terms of seed yield and an SC% of 0.169 vs. the average of 0.363 of both cultivars. Little is known about the cause of low seed yield. An understanding of seed yield components is, therefore, essential with Tainan Selection No.2 as the ideal material for this study.

In experiment 3 (Table 11), TK 70 showed no significant differences from TM 103 and PT 858 in seed yield and PT 858 and PT 862 in SC%.

Other significant factors were the plastic sheet mulching and fertilization in experiment 2, and the inter-row and intra-row spacings in experiment 4. The harvest 3 of experiment 2 was significantly poorer than that of the no-mulching treatment from that with mulching. However, the seed conversion percentage in the mulching treatment was significantly the lowest in the whole experiment. Fertilization

with higher top dressings of 60 N and 60 K_2O (no P_2O_5) at three and six weeks after transplanting significantly increased both seed yield and SC% in the fourth harvest. Since the contribution of seed yield in this harvest was only 14.87% of the total, it was therefore not large enough to show up in the comparison of final yields.

Table 10. Seed weight and seed conversion percentage of the autumn tomato trial after second rice cultivation.[z]

Source of Variation	Harvest 1		Harvest 2		Harvest 3		Harvest 4		Total	
	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)
Mulching vs. non-mulching (main)	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.	*
Cultivar (C) (sub)	n.s.	**	n.s.	***	*	***	n.s.	***	*	***
M x C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Fertilization (F) (ssub)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	**	n.s.	n.s.
M x F	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
C x F	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
M x C x F	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mean	75.8	0.298	133.5	0.366	334.2	0.483	95.0	0.409	638.5	0.414
Coefficient of variation	23.6	10.4	11.5	14.9	14.7	7.3	33.6	9.9	11.9	6.8
% of total harvest	11.9		20.9		52.4		14.9			

Duncan's multiple range test at the 5% level

Harvest 3	plastic mulching	No	Yes		Harvest 1	cultivar	TM 103	PT 858	PT 862
		324.8 b	343.7 a				0.258 b	0.294 b	0.339 a
	cultivar	TM 103	PT 858	PT 862	Harvest 2	cultivar	TM 103	PT 858	PT 862
		289.8 b	337.4 ab	375.5 a			0.341 b	0.339 b	0.419 a
Harvest 4	fertilization	Regime 1	Regime 2		Harvest 3	cultivar	TM 103	PT 858	PT 862
		75.3 b	114.6 a				0.409 c	0.493 b	0.549 a
Total	cultivar	TM 103	PT 858	PT 862	Harvest 4	cultivar	TM 103	PT 858	PT 862
		578.6 b	630.0 b	706.8 a			0.344 c	0.389 b	0.495 a
						fertilization	Regime 1	Regime 2	
							0.384 b	0.434 a	
					Total	plastic mulching	No	Yes	
							0.419 a	0.408 b	
						cultivar	TM 103	PT 858	PT 862
							0.355 c	0.409 b	0.478 a

[z]sw = seed weight; sc% = seed conversion ratio minus; n.s. = no significance; * = significant at the 5% level; ** = significant at the 1% level.

Table 11. Seed weight and seed conversion percentage of tomato on the soil amendment trial.[z]

Source of Variation	Harvest 1		Harvest 2		Harvest 3		Harvest 4		Total	
	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)
Soil amendment (S) (main)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Replicate	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Cultivar (C)	n.s.	n.s.	**	*	n.s.	**	n.s.	n.s.	n.s.	**
S x C	n.s.	n.s.	n.s.	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mean	63.0	0.412	107.9	0.358	423.2	0.489	375.0	0.448	969.0	0.444
CV	24.0	52.6	15.2	8.4	14.9	6.7	18.5	7.8	12.7	6.6
% of total harvest	6.5		11.1		43.7		38.7			

Table 11. Continued.

Duncan's multiple range test at the 5% level

Harv. 1	cv.	TM 103	PT 858	PT 862	TK 70	Harv. 1	cv.	TM 103	PT 858	PT 862	TK 70
		67.2 a	65.2 ab	73.8 a	45.8 b			0.297 b	0.318 b	0.400 ab	0.633 a
Harv. 2	cv.	TM 103	PT 858	PT 862	TK 70	Harv. 2	cv.	TM 103	PT 858	PT 862	TK 70
		116.3 ab	103.2 b	136.1 a	76.0 c			0.343 b	0.328 b	0.395 a	0.365 ab
Harv. 3	cv.	TM 103	PT 858	PT 862	TK 70	Harv. 3	cv.	TM 103	PT 858	PT 862	TK 70
		388.5 b	416.2 ab	486.2 a	401.9 ab			0.410 c	0.492 b	0.548 a	0.505 b
Total	cv.	TM 103	PT 858	PT 862	TK 70	Harv. 4	cv.	TM 103	PT 858	PT 862	TK 70
		914.6 b	859.0 ab	1086.3 a	916.1 b			0.420 b	0.438 ab	0.485a	0.450 ab
						Total	cv.	TM 103	PT 858	PT 862	TK 70
								0.390 c	0.432 b	0.488 a	0.465 ab

[z]sw = seed weight, sc = seed conversion ratio minus; n.s. = no significance; * = significant at the 5% level, ** = significant at the 1% level

Table 12. Seed weight and seed conversion percentage in the trial on the effect of spacing on the growth and yield of tomato.[z]

Source of Variation	Harvest 1		Harvest 2		Harvest 3		Harvest 4		Total	
	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)	sw(g)	sc(%)
Cultivar										
Line (main)	*	*	**	**	n.s.	*	n.s.	*	*	***
Row spacing (sub)	n.s.	n.s.	*	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
C x RS	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Intrarow spacing (ssub)	n.s.	n.s.	**	*	**	n.s.	n.s.	n.s.	**	n.s.
C x IS	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
RS x IS	n.s.	n.s.	n.s.	n.s	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
C x RS x IS	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Mean	20.1	0.225	63.7	0.301	47.8	0.302	14.3	0.291	145.9	0.288
CV	35.5	25.4	21.3	8.1	21.1	25.8	45.1	20.1	14.2	10.3
% of total harvest	13.8		43.7		32.8		9.8			

Duncan's multiple range test at the 5% level

Harvest 1	cultivar	TN #2	TM 103	PT 862	Harvest 1	cultivar	TN #2	TM 103	PT 862
	mean	4.0 b	25.5 a	30.7 a			0.113 b	0.358 a	0.203 b
Harvest 2	cultivar	TN #2	TM 103	PT 862	Harvest 2	cultivar	TN #2	TM 103	PT 862
	mean	13.6 b	84.4 a	93.2 a			0.103 c	0.456 a	0.344 b
	row spacing	1.0 m	1.2 m	1.5 m		intrarow spacing	0.3 m	0.4 m	0.5 m
	mean	54.7 b	68.2 a	68.3 a			0.311 a	0.288 b	0.305 a
	intrarow spacing	0.3 m	0.4 m	0.5 m	Harvest 3	cultivar	TN #2	TM 103	PT 862
	mean	77.4 a	63.1 b	50.7 c			0.154 b	0.461 a	0.290 b
Harvest 3	cultivar	TN #2	TM 103	PT 862	Harvest 4	cultivar	TN #2	TM 103	PT 862
	mean	21.6 b	47.6 ab	74.2 a			0.169 b	0.402 a	0.301 a
	intrarow spacing	0.3 m	0.4 m	0.5 m	Total	cultivar	TN #2	TM 103	PT 862
	mean	54.9 a	41.6 b	46.8 b			0.137 c	0.431 a	0.295 b
Harvest 4	row spac.	1.0 m	1.2 m	1.5 m					
	mean	17.2 a	10.6 b	15.1 a					
Total	cultivar	TN #2	TM 103	PT 862					
	mean	53.1 b	172.7 a	211.9 a					
	intrarow spacing	0.3 m	0.4 m	0.5 m					
	mean	169.8 a	136.9 b	131.0 b					

[z]sw = seed weight; sc% = seed conversion ratio minus; n.s. = no significance; * = significant at the 5% level; ** = significant at the 1% level

In experiment 4, both interrow and intrarow spacings affected seed yield. However, interrow spacing showed inconsistent results in harvests 2 and 4. Furthermore, harvest 4 only contributed 9.81% of the total seed yield. Interrow spacing therefore did not reflect itself in the final seed yield analysis. Intrarow spacing might be a more important factor. It gave significant differences at 1% level in harvests 2, and 3, and in the final seed yield. Smaller intrarow spacing at 0.3 m reportedly increased fruit yield in Tainan No. 2 and TM 103 which probably also increased seed yield.

Conclusion

The cultivar or line is the most important determinant of seed yield. A cultivar is usually released without considering seed yield, making it difficult for the seed producer. It is, therefore, important to understand the different seed components in order to improve seed yield.

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Office of Information Services

According to the 'Report of the Third External Review' the objectives of the Office of Information Services (OIS) are to assist in increasing the level of communication between AVRDC researchers and their colleagues working in national programs; to assist in the dissemination of the Center's finished research products; and to serve as a link between the Center, its donors, and other parties interested in AVRDC activities.

Publication

OIS primarily accomplishes its communication function by publishing AVRDC research work. In 1985 OIS published 45,650 copies of 23 documents with 2,193 pages (Table 1).

During 1985 OIS took the following publication initiatives:

1985 progress report. In order to communicate AVRDC research results as quickly as possible, the schedule for the *1985 Progress Report* was moved up three months earlier than in previous years and was available by the Progress Planning Workshop in mid-December 1986. This was accomplished despite the nonarrival of needed computerized equipment: i.e., terminal, hard disc storage and typesetter.

Progress report summaries. The availability of the new Heidelberg press and the inexpensive addition of a modest amount of color, provided a new appearance to the *AVRDC Progress Report Summaries 1984*. The *AVRDC Progress Report Summaries 1985* was scheduled to be available by the end of the second quarter, in time for the June CGIAR Centers' Meeting, but unforeseen high-priority work moved the deadline towards the end of the third quarter.

Scheduling of publications. OIS has begun to take the initiative in scheduling the preparation of documents by moving up the publication date for the *1985 Progress Report*. Further success will depend, in part, on the arrival of needed document-preparation equipment.

Highlights. The *1984 AVRDC Highlights* was translated into five languages (English, German, Indonesian, Korean, and Thai) and published during the third and fourth quarters of 1985. The *1985 AVRDC Highlights* was prepared in an attractive color-photograph brochure in seven languages (Chinese, English, French, German, Indonesian, Japanese, and Korean) and published during the first and second quarters of 1986.

Copublication. OIS obtained a grant from the Technical Centre for Agricultural and Rural Cooperation (CTA) to translate the published AVRDC *Sweet Potato Proceedings* in French. A translator, reviser, and French publishing company were identified with assistance from Board member Dr. Guy Vallaeys. OIS is negotiating to have *Soybean in Tropical and Subtropical Cropping Systems* copublished in Chinese.

Public Relations

During 1985 many articles about AVRDC activities appeared in the local press and in the international specialized press which deals particularly with agricultural development issues. During

Table 1. 1985 OIS publication schedule.

Publication	No. of Copies	Pages	Total No. of Pages	Quarter Published[z]	TVIS
Documents					
Soybean Cropping Systems Proceedings	3,500	488	1,708,000	3rd	–
1983 Progress Report	1,250	466	582,500	2nd	–
1984 Progress Report Summaries	3,500	96	336,000	3rd	–
Annotated Bibliography of Diamondback Moth	1,000	484	484,000	1st	x
Soybean Trials	300	86	25,800	4th	x
Mungbean Trials	300	62	18,600	4th	x
Int. Cooperator's Guide: Sweet Potato Germplasm	500	2	1,000	3rd	–
Int. Cooperator's Guide: Handling of Sweet Potato Germplasm	500	4	2,000	3rd	–
Highlights (English)	10,000	2	20,000	3rd	–
Highlights (German, Indonesian, Korean, and Thai)	2,000	2	4,000	4th	–
Training Course Syllabus	500	1	500	4th	–
AVRDC Publication Catalog 1985	500	10	5,000	3rd	–
Subtotal	23,850	1,703	3,187,400		
Periodicals					
AVRDC Newsletter (weekly)	200	216	43,200	1st-4th	–
CENTERPOINT (Dec.'84)	6,000	4	24,000	1st	–
CENTERPOINT (July'85)	8,000	4	32,000	3rd	–
TVIS News Vol. 1, No. 1	2,500	24	60,000	2nd	x
Soybean Rust Newsletter, Oct. 1985	1,000	40	40,000	4th	x
Subtotal	17,700	288	199,200		
Reprints					
Pre- & Post-Harvest Vegetable Technology in Asia	1,000	64	64,000	1st	–
Technical Bulletin No. 9	800	68	54,400	1st	–
Technical Bulletin No. 11	400	28	11,200	2nd	–
Technical Bulletin No. 13	400	38	15,200	2nd	–
Int. Cooperator's Guide: Suggested Cultural Practices for Tomato	1,500	4	6,000	4th	–
Subtotal	4,100	202	150,800		
Total	45,650	2,193	3,537,400		

[z]Quarter of the year: 1st (January to March), 2nd (April-June), 3rd (July to September), and 4th (October to December).

the year OIS prepared three news releases for international, as well as local, distribution. Groups of foreign journalists visit AVRDC every other month, on the average. During the second half of 1985, OIS fully briefed journalists from the following countries: Argentina, Colombia, Costa Rica, Chile, Dominican Republic, Ecuador, El Salvador, Guatemala, Panama, Paraguay, Peru, Thailand, Uruguay, and Venezuela. OIS also prepared hundreds of briefing kits for VIP visitors to the Center. These kits contain the *Centerpoint* newsletter which is prepared completely by OIS, the *Highlights* brochure in the required language, the Training brochure, and the most recent issue of the *Progress Report Summaries*. OIS also ran the slide show in the auditorium for 57 groups of visitors during 1985.

Data Bases

With technical assistance from the Computer Services, OIS has established two data bases for the Center: the Mailing List and the OIS Slide File (Figs. 1 and 2). Since the data bases are in the HP 3000, they are accessible through any HP terminal in the entire Center.

MAILING LIST DATA BASE

NAME OF PERSON
FAMILY NAME
GIVEN NAME
ORGANIZATION
ADDRESS LINES
COUNTRY
INTERESTS
CODE
TELEPHONE NUMBER
TELEX/CABLE
ANSWERED UPDATE
RECEIVED DATE

Fig. 1. Mailing list

OIS SLIDE FILE DATA BASE

UNIQUE NUMBER
KEYWORD DESCRIPTION
ONE SENTENCE DESCRIPTION
DATE (MONTH & YEAR)
FORMAT (VERTICAL OR HORZONTAL)
PHOTOGRAPHER
SLIDE
PHOTO
NEGATIVE NUMBER
USED (AVRDC NO.)

Fig. 2. Slide file

During the second and third quarters of 1985, the separate *TVIS News* and *Soybean Rust Newsletter* mailing lists were merged with the OIS Mailing List. A year-long exercise to update the entire 7,000-entry list began: readers' responses were solicited, addresses corrected or dropped from the list if not answered, and additional information concerning telephone numbers, telex and cable addresses was incorporated. By the end of 1985 the updating exercise was still underway.

The OIS Slide File has been established, and as soon as the expected terminal arrives, information on selected slides will begin to be entered for easy use by the Center staff through computer key-word search.

Editing/Authoring Services

During the second half of 1985, OIS authored one issue of *Centerpoint* and the *1984 Progress Report Summaries*. In the same period, nine documents, two periodicals, four journal papers, six symposium presentations, and five informal papers were edited by OIS.

Journal Papers and Symposium Presentations

The caliber of any research institute can be measured by the degree to which its researchers publish their findings in the major primary journals. During 1985 a total of eight journal papers by AVRDC scientists were published, and five articles were prepared for publication (see publications section). Although not to be considered primary literature, sympoisum/workshop proceedings are often published and widely read in the scientific community. During 1985, 17 symposium papers were presented by AVRDC scientists.

Printing Services

The printshop processed 527 separate requests from all branches of AVRDC in 1985. This represented a total of 1,582,000 pages. The discrepancy between this figure and the 3,537,400 pages listed in Table 1 is represented by several large publications which were printed by commercial printers. The 1985 total number of printed pages was less than in 1984 because the reprinting of some major jobs, e.g., the *Chinese Cabbage Symposium Proceedings*, has been postponed until needed equipment arrives.

Photo Services

Based on past improvements through the development and/or adaption of studio techniques and technical processes, the OIS photographic unit continued to provide quality services while reducing costs (Tables 2 and 3).

Table 2. Photographic services 1984-1985.

Year	Color Slides	Blue Slides	B/W Prints	Color Prints	Total
1984	8,301	2,084	5,035	-	15,420
1985	11,135	3,590	5,059	772	20,556

Table 3. Photographic costs 1981-85 (US$).[z]

	1981	1982	1983	1984	1985
Processing	4,064	3,354	4,232	2,282	1,685
Supplies	4,661	3,859	3,535	3,193	3,641
Sales	- 216	- 445	-1,288	- 941	-1,935
Total	8,509	6,772	6,479	4,534	3,391

[z]NT $39.85 = US $1.

Art Services

The art services unit processed 95 requests, excluding work commissioned by OIS, for figures, tables, etc. during 1985. The total number of illustrations exceeded 500. Unlike in the photo and printing units, the artist works alone. The artist regularly receives assistance from the printing assistant, as print wor' flows. Among the most time-consuming tasks of the art unit is the layout of OIS publications. In the past the traditional cut-and-stick method has been used.

Distribution

Distribution is the final leg of OIS work after the long document preparation process. A total of 1,590 requests for publications were received in 1985, excluding requests for progress report reprints. OIS maintains the Center's mailing list. During the last half of 1985, a thorough updating was initiated. Addressees of the TVIS project were also incorporated into the mailing list data base. After completing the mailing list update, the Center has 4,500 entries in the listing, a reduction of 25% from the previous year. This reduction in readers should be seen as a benefit to AVRDC, since the cost in printing and distribution of an incorrect or uninterested listing can range from US$3 to US$5/year for an addressee in the general category to US$20 to US$30 year for a library listing.

AVRDC is not financially able to provide free copies of all of its publications to its entire potential clientele even if they could be identified. For this reason in 1983, AVRDC established a two-tiered policy of providing its publications free-of-charge to all bona fide libraries on its mailing list while charging for its large documents requested by individuals.

Commercial book sellers are a useful channel for reaching unknown clientele, as well as to generate funds through increased book sales, funds which can be used to sustain communication efforts. OIS has increased its receipts from book sales as it has increased its number of commercial outlets (Figs. 3 and 4).

Book fairs can provide a useful forum for contacting potential copublishers and commercial book sellers. The exhibitions at the Frankfurt International Bookfair, the Zimbabwe International Book Fair, and the Hunan Exposition during 1985 facilitated arrangements for a major copublication, enlarged AVRDC's commercial book sellers' network, and permitted direct increases in sales. When orders are taken from exhibition visitors at the book fair, as was the case at the Hunan Exposition, direct sales occur. The IARC which coordinates participation at book fairs should arrange for a local book seller to take orders. Through its new commercial outlet in the USA, AVRDC has begun to have selected titles exhibited at some major scientific meetings, i.e., the American Society of Agronomy and the Entomology Society of America.

Mailing costs continued their inexorable rise in 1985 to US$15,744 from US$10,184 in 1984. This is due to rising postage costs and the increased mailings of the TVIS project.

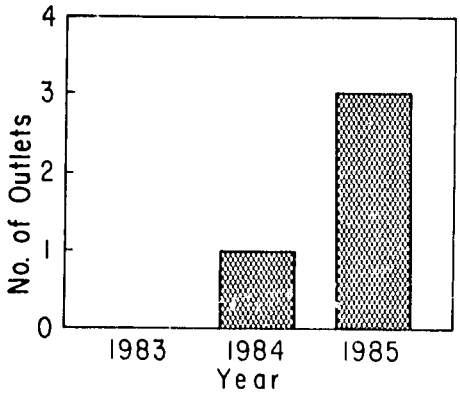

Fig 3. AVRDC publication outlets, 1983-85

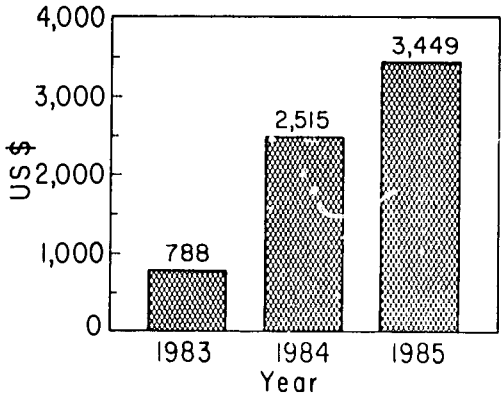

Fig. 4. Receipts from AVRDC publications, 1983-85

Need for Processing Facilities

Because of the nature of information work, OIS has been in the vanguard at AVRDC to introduce new technology to the work place. In 1982 OIS obtained the first word processing unit, the IBM Displaywriter, at the Center. With the introduction in 1984 of the HP 150 to the entire Center, this computer has become the standard word processor for work on reports, such as the annual progress report.

- **Document preparation.** Currently, however, OIS is unable to take advantage of many of the improved possibilities that the computer age offers. The availability to OIS of only one terminal presents a serious constraint. It must be used for the maintenance of the mailing list, the development of the new OIS slide file data base by the distribution and art units, and electronic editing by the two-member editorial staff. The absence of a memory storage unit in which files of large documents can be held for electronic editing is another serious constraint.

- **Typesetting.** Currently, AVRDC has no printer capable of print-quality resolution by the HP computer. This necessitates the use of external commercial typesetting which is costly and does not efficiently use the limited resources of the artist.

- **Printing.** OIS was fortunate to obtain a new, large Heidelberg press during 1985. This press is particularly advantageous for large print-runs and color work. However, additional equipment large enough to service this press is urgently required.

Office of Training and International Cooperation

In June 1985 the Training and Development Office was renamed Office of Training and International Cooperation (OTIC). The development responsibilities of the former office were transferred to the Production Systems Program; and International Cooperation, involving current outreach programs, was added to the latter. The responsibilities are as follows:

1. Plan the training program and arrange for the selection of scholars
2. Execute the training program through cooperation and coordination with appropriate resource persons
3. Arrange and execute regional or national training programs in cooperation with local bodies as appropriate
4. Provide back-up support and expertise for ongoing AVRDC/national training programs, e.g.,Thailand Outreach Program
5. Act as liaison with resident scientists and/or designated national scientists and appropriate AVRDC staff to provide agreed upon requirements of ongoing outreach programs in a timely and efficient way
6. Serve as the AVRDC contact person for outreach/bilateral programs

Training Activities

Enrollment

Ninety-four individuals from 14 countries reported to AVRDC Headquarters for training in 1985 (Table 1). A total of 90% represented the six participating Asian countries, and the rest came from eight nonparticipating countries in Asia, Africa, and the more developed countries of the world. AVRDC spent 303 man-months, equivalent to 25.3 man-years, training the 94 scholars.

Funding Sources

AVRDC provided 26% of the total scholarship grants (US$280,000) and the rest came from the following sources:

1. ADB Technical Assistance Grant to the AVRDC-Indonesian Outreach Program
2. ADB Technical Assistance Grant to the AVRDC-Malaysian Outreach Program
3. AVRDC-Thailand Outreach Program (TOP)
4. ADB Loan Grant to the Second Laguna de Bay Irrigation Project - Vegetable Component, M. A. F., Philippines
5. World Bank-Assisted Seed Project - Indonesia
6. Rural Development Administration - Korea
7. ROC-VACRS Assistance to the King's Project
8. ROC-National Science Council
9. Japan International Cooperation Agency (JICA)

Table 1. Number of scholars by country and duration of scholarship, 1985.

Country	No. of Scholars	Man-Months
Participating		
1. Indonesia	16	66.0
2. Korea	5	22.0
3. Malaysia	17	39.0
4. Philippines	8	40.0
5. Taiwan	28	69.5
6. Thailand	11	29.0
Subtotal	85	265.5
Nonparticipating		
7. Bangladesh	1	0.5
8. Japan	1	11.0
9. Liberia	1	5.0
10. Papua New Guinea	1	5.0
11. Reunion	1	1.0
12. Tonga	1	5.0
13. U. S. A.	2	8.0
14. West Germany	1	2.0
Subtotal	9	37.5
Total	94	303.0

10. German Agency for Technical Cooperation (GTZ)
11. German Academic Exchange Service
12. Netherlands Universities Foundation for International Cooperation (NUFFIC)/University of Brawijaja
13. USAID Garden Program
14. University of Illinois
15. Canho Enterprise Co., Ltd.
16. Adams International, Ltd.
17. Board of Global Ministries, United Methodist Church - USA
18. Self-sponsorship

AVRDC Staff Training Load

As advisers. The AVRDC senior and junior staff were very much involved as advisers to training scholars, especially those coming as research interns, scholars, fellows, and summer students (Table 2). In many instances the interns, scholars, and fellows developed their own research problems with the adviser's guidance. The others simply carried on the ongoing research activities of their advisers. Summer students are usually involved in ongoing research projects. Therefore, we do not only accomplish the project but also provide them with skills and experiences.

As resource persons. Aside from acting as advisers to the scholars, the staff, both seniors and juniors, provided time as resource persons to the group courses at AVRDC. The tendency to utilize junior staff more as resource persons was very evident in 1985. Our competent junior staff showed more confidence in handling lectures in English. In the spring course 67% of the resource persons were senior staff, 21% junior staff, and 12% outsiders. In the fall 54% were senior staff, 38% juniors, and 8% outsiders. Outside resource persons with expertise that the Center lacks were invited. A professor from the National Taiwan University provided lectures on some aspects of agricultural economics. Vegetable preparation and cooking classes were also handled by invited resource persons.

Table 2. Distribution of training scholars by subject/discipline and period of training, AVRDC 1985.[z]

Subject/Discipline	RI	RS	RF	PT	SPT	VS	SST	Total	Man-Months
Plant Breeding	2	1	–	–	–	2	4	9	35.0
Plant Pathology	3	–	–	–	2	2	2	9	24.5
Plant Physiology	1	–	–	–	–	–	4	5	13.0
Entomology	1	–	–	–	–	2	5	8	17.0
Seed Technology	1	–	–	–	–	–	2	3	9.0
Chemistry	–	–	–	–	1	–	9	10	25.0
Crop Management	–	–	–	–	–	4	–	4	4.0
Economics	–	1	–	–	–	–	–	1	7.0
Garden/Nutrition	–	–	–	–	2	–	–	2	1.5
Soil Science	2	–	1	–	2	–	–	5	22.0
Production	–	–	–	26	1	–	–	27	124.5
Information	–	–	1	–	–	–	–	1	12.0
Research Management	–	–	–	–	–	6	–	6	4.0
Training Management	–	–	–	–	1	–	–	1	3.0
General	–	–	–	–	3	–	–	3	1.5
Total	10	2	2	26	12	16	26	94	303.0

[z]RI: Research Intern; RS: Research Scholar; RF: Research Fellow; PT: Production Trainee; SPT: Special Purpose Trainee; VS: Visiting Scientist; SST: Summer Student Trainee.

Training Services for the Outreach Programs

Providing AVRDC outreach operations with trained manpower is given the highest priority in our training program. Seventy-eight percent of the total enrollment for 1985 came from the six participating countries where we have active outreach programs (Table 3). The highest numbers came from Malaysia and Indonesia where the outreach programs were recently inaugurated. The training of technical personnel to man the multilocational trials was given emphasis. Malaysia and Indonesia sent not only frontline research workers, but also middle- and senior-level researchers for exposure and orientation to the research and training systems at AVRDC.

Table 3. Training services for the outreach programs, December 1985.

Countries	Outreach Prog.	Nat./Other Prog.	Total
Participating			
1. Indonesia	16	–	16
2. Korea	4	1	5
3. Malaysia	17	–	17
4. Philippines	5	3	8
5. Taiwan	26	2	28
6. Thailand	5	6	11
Subtotal	73	12	85
Nonparticipating			
7. Bangladesh	–	1	1
8. Japan	–	1	1
9. Liberia	–	1	1
10. Papua New Guinea	–	1	1
11. Reunion	–	1	1
12. Tonga	–	1	1
13. U. S. A.	–	2	2
14. West Germany	–	1	1
Subtotal	0	9	9
Total	73	21	94

As part of our responsibility, we provided the AVRDC-TOP Regional Training Course with resource persons upon request by the resident scientist. Ten senior staff were requested to deliver lectures in the regional course as part of their official travel to the region. Lectures were given on areas that local resource persons could not otherwise provide, especially those involving critical AVRDC activities, e.g., plant breeding, plant physiology, plant pathology including virology, entomology, home gardening, germplasm evaluation and utilization, and scientific report writing.

The First Training Decade

AVRDC completed the first 10 years of its formal training services to Taiwan and foreign nationalities. Table 4 shows the training output of 677 graduates from 40 countries. The total included 49 graduates from 10 countries of four Regional Training Courses at AVRDC-TOP conducted in the last three years.

Of the total graduates 84% represented both outreach and national/other programs in participating countries. Of those coming from participating countries, 29% were trained for the operations of the outreach programs.

Our activities in full support of the ongoing outreach programs began in June 1985. Presently we have six ongoing outreach programs in six countries (Table 5).

Table 4. AVRDC graduates 1974 to 1985.

Countries/Regions	Outreach Prog.	Nat./Other Prog.	Total
Participating			
1. Indonesia	16	44	60
2. Korea	35	9	44
3. Malaysia	17	13	30
4. Philippines	27	95	122
5. Taiwan	26	196	222
6. Thailand	43	47	90
Subtotal	164	404	568
Nonparticipating			
Asia and the Pacific - 13 countries	–	65	65
Latin America - 9 countries	–	13	13
Africa South of the Sahara	–	8	8
More Developed Countries of the World - 6 countries	–	23	23
Subtotal	0	109	109
Total	164	513	677

Table 5. AVRDC outreach stations and cooperators.

Country	Cooperating Agencies
Indonesia	Agency for Agricultural Research and Development (AARD)
Korea	Rural Development Administration (RDA)
Malaysia	Malaysian Agricultural Research and Development Institute (MARDI)
Philippines	Bureau of Plant Industry (BPI)
Taiwan	Provincial Department of Agriculture and Forestry (PDAF)
Thailand	Kasetsart University (KU)

Goals for 1986

1. Continue to offer two courses in Vegetable Production Training
2. Conduct the initial course on Biological Control of Diamond-back moth in cooperation with the Entomology Department
3. Initiate the negotiation and planning for more in-country training programs
4. Continue to backstop ongoing regional courses in Thailand
5. Provide assistance to outreach resident scientists as liaison with headquarters staff

Training Scholars

Plant Breeding

Amnart Chinchest; Thailand
Kim, Soo Dong; Korea
Lain, Kuo Jou; Taiwan
Lee, Yii Shien; Taiwan
Lin, Ling Na; Taiwan
Melor Rejab; Malaysia
Milo, Victoria C.; Philippines
Wang, Shyh Shyan; Taiwan
Wu, Erika; Taiwan

Plant Pathology

Anek Chotiyarnwong; Thailand
Bizer, Eberhard J.; West Germany
Choi, Seong Ho; Korea
Ho, Ban Lee; Malaysia
Liao, Huey Jane; Taiwan
Mah, Shook Ying; Malaysia
Manoj Panyapinyophol; Thailand
Montha Nuntapunt; Thailand
Wang, Jen Yeu; Taiwan

Plant Physiology

Chang, Char Yi; Taiwan
Chang, Ruey Ling; Taiwan
Kim, Won Bae; Korea
Li, Thu Chen; Taiwan
Su, I Zen; Taiwan

Entomology

Chen, Chian Leei; Taiwan
Esguerra, Nelson P.; Philippines
Hong, Chien Fu; Taiwan
Li, Ming Chen; Taiwan
Siti Asmah Dzayauddin; Malaysia
Syed Abdul Rahman; Malaysia
Wu, Huey Lin; Taiwan
Yiin, Yii Fei; Taiwan

Seed Technology

Hsu, Wen Chi; Taiwan
Shiue, Mei Luen; Taiwan
Suarti Soetadi; Indonesia

Chemistry

Chen, Hsiou Jeng; Taiwan
Cheng, Jason; Taiwan
Chiu, Horng Yih; Taiwan
Ha, Choi Lan; Taiwan
Ladines, Evelyn O.; Philippines
Leu, Fang Jiuan; Taiwan
Liang, Ing Raang; Taiwan
Lin, Ming Feng; Taiwan
Liu, Huey Jiuan; Taiwan
Lu, Hsi Chi; Taiwan

Crop Management

Engku Ismail Engku Ahmad; Malaysia
Khelikuzzaman bin Meera Hussain; Malaysia
Leong, Ah Chye; Malaysia
Michellon, Roger; France

Economics

Gleason, Jane; U.S.A.

Garden/Nutrition

Brown, Allison A.; Thailand
Sarkar, Asit K.; Bangladesh

Soil Science

Kamata, Kazuhiko; Japan
Lin, Jiunn Yann; K. Saudi Arabia
Park, Sang Gu; Korea
Somkiat Khamiam; Thailand
Yusdar Hilman; Indonesia

Production Training Program

Abdul Rashid bin Endut; Malaysia
Ahmad Faried Fadhly; Indonesia
Arandia, Sixto M.; Philipines
Asnimar Alwi; Indonesia
Azizan bin Ahmad; Malaysia
Budi Santoso; Indonesia
Cachero, Pacifico P.; Philippines
I Wayan Kartha; Indonesia
Ida Noordijati Kusman; Indonesia
Khairul Anuar Zainol Abidin; Malaysia
Lah, Luogon P.; Liberia
Lim, Sang Cheol; Korea
Magpantay, Democrito Z. Philippines
Marsono Partodinamo; Indonesia
Miranda, Nestor L.; Philippines
Nanay Jubaida Mashudi; Indonesia
Osilis, Paul; Papua New Guinea
Pairat Kamdee; Thailand
Ramli bin Omar; Malaysia
Sanusi Karyadhara; Indonesia
Surtikanti; Indonesia

Tata, Rasta Omoy; Indonesia
Vaea, Sione Malamala; Tonga
Wannarat Na-anant; Thailand
Witono Adiyoga; Indonesia
Wiwin Windasah Soewarman; Indonesia
Yeong, Nam Hin; Malaysia

Information Management

Lastimosa, Pura; Philippines

Research Management

Abdul Rahman Daud; Malaysia
Abdul Rahman Haron; Malaysia
Ali bin Abdul Hamid; Malaysia
Anggoro Hadi Permadi; Indonesia
Lim, Heng Jong; Malaysia
Saubari M. Mimbar; Indonesia

Training Management

Yuenyong Ounthammaratana; Thailand

General Topics

Chatchawan Hipprasart; Thailand
Korakot Boontam; Thailand
Narong, Boonkaw; Thailand

Appendix

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Board of Directors

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Food Industry Research and Development Institute
Taiwan, ROC

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Dr. Jung-Ho Kim
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German Agency for Technical Cooperation
Federal Republic of Germany

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E. Brunswick, N.J.
USA

Dr. Chongrak Prichananda
Kasetsart University
Thailand

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Department of Agriculture
USA

Dr. M. Guy Vallaeys
Inter-Ministerial Committee of International Agricultural Research
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Ministry of Agriculture and Food
Philippines

Dr. R. V. Valmayor
Philippine Council for Agriculture and Resources Research and Development
Philippines

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Asian Vegetable Research and Development Center
(Until September)

Dr. Paul M. H. Sun
Asian Vegetable Research and Development Center
(After September)

Dr. T. C. Tso
Plant Genetics and Germplasm Institute
USA

Observers

Mr. F. T. Chang
Council for Agricultural Planning and Development
Taiwan, ROC

Ms. Deborah R. Schwartz
American Institute in Taiwan
USA

Dr. John S. Robins
Agency for International Development
USA

Mr. D. F. Panganiban
Ministry of Agriculture, Philippines
(Representing Minister Escudero)

Mr. Takasuke Yamaguchi
Interchange Association
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George A. Marlowe, Jr., Ph.D., Director General#
Paul M. H. Sun, Ph.D., Deputy Director General
Michael Chin, B.S., Director of Administration
David I. K. Chi, G.A., C.P.A., Comptroller
Chen Jeng-hua, B.S., Superintendent, Buildings and Maintenance**
Ann Hwa, Manager, Food and Dormitory Services

Tomato Breeding

Romeo T. Opeña, Ph.D., Program Leader (Horticulture) and Plant Breeder (tomato)
Jen-tzu Chen, Assistant Specialist

Chinese Cabbage Breeding

Jin Young Yoon, Ph.D., Associate Plant Breeder**
Lien-chung Chang, B.S., Assistant Specialist

Mungbean Breeding

George C. J. Fernandez, Ph.D., Research Associate#
Ren-chein Jin, B.S., Research Assistant
Miao-miao Hsu, M.S., Principal Research Assistant*
Hao-koan Chen, M.S., Principal Research Assistant***

Soybean Breeding

S. Shanmugasundaram, Ph.D., Program Leader (legumes) and Plant Breeder (soybean)+
Kun-te Lee, Senior Research Assistant
Li-fen Chen, M.S., Principal Research Assistant

Sweet Potato Breeding

Steve S. M. Lin, Ph.D., Associate Plant Breeder (sweet potato and processing tomato breeder)++
Masaru Iwanaga, Ph.D., Visiting Scientist from CIP**
Hiroko Takagi, Ph.D., Research Associate#
Ching-hsiung Hung, M.S., Principal Research Assistant*
Chei-shan Cheng, B.S., Senior Research Assistant*

Plant Pathology

Arnold T. Tschanz, Ph.D., Plant Pathologist (legumes), Head, Plant Pathology

Tien-cheng Wang, B.S., Associate Plant Pathologist
Min-chu Tsai, M.S., Principal Research Assistant*
Yao-hua Cheng, B.S., Research Assistant
Ming-ming Chao, M.S., Principal Research
Sylvia K. Green, Ph.D., Associate Plant Pathologist (virology)
Dar-ren Lee, M.S., Principal Research Assistant
Yen-jen Kuo, M.S., Principal Research Assistant**
Jonathan E. Yuen, Ph.D., Associate Plant Pathologist (horticulture)/computer specialist*
Hsiou-chen Huang, M.S., Principal Research Assistant*
Hao-jan Lin, B.S., Research Assistant

Entomology

N. S. Talekar, Ph.D., Entomologist
Hui-chin Yang, B.S., Research Assistant*
Song-tay Lee, B.S., Research Assistant##
Chih-pin Lin, B.S., Research Assistant
Su-chong Kuo, B.S., Research Assistant*
Shang-wen Hwang, B.S., Research Assistant
Min-yi Liu, M.S., Principal Research Assistant**
Jen-wang Hou, B.S., Research Assistant**
Ying-huey Lee, M.S., Principal Research Assistant**

Plant Physiology

George C. Kuo, Ph.D., Plant Physiologist
Huei-mei Chen, M.S., Principal Research Assistant
Hsiu-chu Chen, M.S., Principal Research Assistant

Chemistry

Samson C. S. Tsou, Ph.D., Program Leader, Production Systems Program (PSP) and Biochemist
Kuang-kung Kan, M.S., Principal Research Assistant
Shyun-shyun Lee, M.S., Principal Research Assistant
Shu-jen Wang, M.S., Principal Research Assistant

Garden Programs

Jack Gershon, Ph.D., Nutritionist
Yen-chin Chen, M.S., Principal Research Assistant*
Lee-ju Chen, M.S., Principal Research Assistant

Soil Science

Hideo Imai, Ph.D., Soil Scientist
Chin-hua Ma, B.S., Research Assistant
Chi-hsin Lu, M.S., Principal Research Assistant

Crop Management

Adisak Sajjapongse, Ph.D., Associate Crop Management Specialist###
Bernard A. Kratky, Ph.D., Visiting Scientist from University of Hawaii, Hilo**
Yu-chi Roan, B.S., Assistant Specialist
Mei-huey Wu, B.S., Senior Research Assistant

Cropping Systems

James J. S. Tsay, Ph.D., Research Associate#

Agricultural Economics

James R. Hicks, Ph.D., Visiting Scientist from Cornell University**,*
Hsu-yu Huang, M.S., Principal Research Assistant*

Soil Microbiology

William C. Stearn, Ph.D., Soil Microbiologist*
Lee-ju Chen, M.S., Principal Research Assistant†††

Training and Development

Diosdado V. Castro, M.S., Training Specialist
Sen-hsiung Lai, B.S., Assistant Development Officer***
Yuan-chin Yang, B.S., Training Assistant
Jia-chi Cheng, B.S., Training Assistant

Information Services

E. W. Sulzberger, M.A., Associate Information Specialist*
Bruce T. McLean, B.A., Associate Information Specialist**
Lastimosa, Pura J., M.A., Assistant Information Specialist**

Library

Teng-hui Hwang, B.A., Senior Librarian
Chen Nein-ming, M.S., Documentalist**,*

Experimental Farm

Teng-sheng Tu, B.S., Farm Superintendent

Genetic Resources and Seed Unit (GRSU)

Chong Seng Tay, Ph.D., Research Associate
Yung-kuang Huang, B.S., Research Assistant
Wen-hsiu Kuo, B.S., Research Assistant
Jin-huei Lu, M.S., Principal Research Assistant**

Statistical Services

Makoto Nagai, B.S., Scientist in Biometry and Head of Statistical Services*
Hsien-yang Tien, B.S., Senior Computer Assistant†
Ming-zen Chang, B.S., Statistical Assistant*

Computer Services

Jonathan E. Yuen, Ph.D., Associate Plant Pathologist (horticulture)/computer specialist*
Hsien-yang Tien, B.S., Computer Assistant†
Yuh-ling, Chen, B.S., Computer Assistant**

Bilateral Programs

Thongchai Tonguthaisri, Ph.D., Resident Scientist#, Indonesia/ AVRDC Bilateral Project, Lembang Horticultural Research Institute, Jalan Tangkuban Peruhu 517, Lembang, Bandung-West Java, Indonesia

Jung Ho Kim, Ph.D., Director, the Korean Sub-Center Affiliated with AVRDC, Horticultural Experiment Station, Rural Development Administration, Suweon, Korea

El Mostafa Saadaoui, Ph.D., Resident Scientist, Malaysia/AVRDC Vegetable Research Program, MARDI, Jalan Kebun, Kelang, Selangor, West Malaysia

Benjamin P. Legaspi, Affiliate Horticulturist, Philippine Outreach Program, Bureau of Plant Industry, Economic Garden, Los Baños, Laguna, Philippines

ROC-AVRDC Outreach Program, Council of Agriculture, 37 Nan-Hai Road, Taipei, Taiwan, ROC

Charles Y. Yang, Ph.D., Director and Resident Scientist, Thailand Outreach Program/AVRDC, P.O. Box 9-1010, Kasetsart, Bangkok 10903, Thailand

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* Left during 1985.
** Arrived during 1985.
*** Reinstatement.
† Sabbatical.
†† Termination upon death.
††† Transferred.
# Arrived in 1986.
Advanced study leave.
Reassignment to CARDI, St. Lucia, West Indies.

Germplasm Recipients 1985

Anguilla, British
INTA Agricultural Experiment Station, Sunni Isle Gardens

Antigua
Caribbean Agricultural Research & Development Institute

Argentina
La Cousulta Experiment Station
Museo Argentino De Ciencias Naturales
Universidad Nacional de Rio Cuarto
Universidad Nacional de Tucuman

Australia
Department of Agriculture, Perth
Redlands Horticultural Research Station
South Australian Department of Agriculture
South Australian Seedgrowers Co.

Austria
Deko Datenservice, GmbH
FAO/IAEA Agricultural Biotechnology Unit

Bangladesh
Bangladesh Agricultural Research Institute
Christian Service Society
Citrus and Vegetable Seed Research Center
Institute of Nuclear Agriculture
University of Chittagong

Belgium
Faculte des Sciences Agronomiques de l'Etat

Belize
Caribbean Agricultural Research and Development Institute

Bhutan
District Administration

Bolivia
Estacion Experimental Gran Chaco

Botswana
Department of Agricultural Research

Brazil
Centro Nacional de Recursos Geneticos
Empresa Maranhense De Pesquisa Agro Pemaria
Lab. Fitopatologia/EMCAPA

Brunei
Pusat Latihan Pertanian Sinaut

Burkina Faso
Canadian Project
IRAT/CIRAD

Burma
IRRI - Burma Project
FAO Representative in Burma

Canada
Horticultural Experiment Station
international Development Research Center (IDRC)
King Grain, Ltd.
Ridgetown College of Agricultural Technology

Chile
Universidad De Tarapaca

Colombia
Centro Internacional de Agricultura Tropical

Cook Islands
Ministry of Agriculture and Fisheries
Rarotonga Exports, Ltd.
Tokoitoku Research Station

Costa Rica
Fertilizantes de Centro America (Costa Rica), S. A.
Proyecto Agroforestal
Taiwan Technical Mission

Cuba
Instituto Nacional De Ciencias Agricolas

Dominican Republic
Semillas Sarenas, S. A.

Ecuador
Leguminosas Costa, Officina Central

Egypt
University of Assiut

El Salvador
Industrials Alimenticias 'EL PANDA'
Vivero Merliot

Ethiopia
Institute of Agricultural Research
Institute of Agricultural Centre

Fiji
Fulton College
The Fiji Sugar Corporation, Ltd.
Legalega Research Station
Sigatoka Research Station
Sugarcane Research Center

France
Centro De Researches Agronomiques

French Guiana
Centre de Polyculture

Gambia
Yundum Agricultural Station

Ghana
Agricultural Experiment Station
Bremens, Ltd.
Crops Research Institute
Dodowa Cooperative Multi-Purpose Society, Ltd.
The Dryland Farming Research and Development Project
Nyankpala Agricultural College
Plant Introduction and Exploration
Rural Farmers Resources and Appropriate Technology

Guatemala (France)
Institut national de la recherche agronomique (INRA)

Guyana
Agrico, S. A.
Guyana Sugar Experiment Station

Haiti
Convention Baptiste D'Haiti
Faculte d'Agronomie et de Medecine Veterinaire
Mennonite Central Committee
Taiwan Technical Mission

Honduras
Escuela Agricula Panamericana
Universidad Nacional Autonoma de Honduras

Hong Kong
Wu Di Christian Center

Hungary
Research Center for Agrobotany

India
Agricultural Research Unit
Andhra Pradesh Agricultural University
Anikur Agricultural Research Laboratory
Central Agricultural Research Institute
Cotton and Millets Experimental Station
Desai Agricultural Farm at Sakhare
Fertilizers Co., Ltd.
G. B. Pant University of Agriculture and Technology

Ganeshkhind Fruit Experimental Station
Haryana Agricultural University
Himachal Pradesh Agricultural University
India Institute of Horticultural Research
Indian Agricultural Research Institute
Khedut Samakari Jin, Ltd.
Kitchen Gardening Society, Ltd.
Nagpur University
National Bureau of Plant Genetic Resources
National Research Centre for Groundnut
Punjab Agricultural University
Punjab Young Farmers Training Centre
Regional Agricultural Research Station
Sakthi Sugars Limited
Tamil Nadu Agricultural University
The University of Agricultural Sciences
Wimco Seedlings, Ltd.

Indonesia
Agricultural Training Center
Balai Benih Induk Sukamenanti
Bogor Agricultural University
Bogor Central Research Institute for Food Crops
Central Research Institute for Food Crops
Cirelon Tedeng Pertanian
Dinas Pertanian Tanaman Pangan
General Soedirman University
Horticultural Research Institute
Indonesia Australia NTT Livestock Development Project
The Irian Jaya Joint Development Foundation
Lembang Research Institute
MARIF
Maros Research Institute for Food Crops
Sub Balai Penelitian Hortikultura
Sukamandi Research Institute for Food Crops
Technical Cooperation for Area Development
Universitas Sriwijaya
West Java at Service

Iran
Seed & Plant Improvement Institute

Israel
Consultant and Engineering Office
The Hebrew University of Jerusalem

Italy
Centre Ricerche
Sementi Hunhems

Jamaica
Plenty Canada
University of the West Indies

Japan
Kagome Research Institute
Kaneko Seed Company
Kikko Foods Corporation
Kirin Brewery Co., Ltd.
National Institute of Agrobiological Resources
Plantech Research Institute
Shizuoka Agricultural Experimental Station
Takii and Company, Ltd.
Tokita Seed Company, Ltd.
Tohoku Seed Company
Vegetable and Ornamental Crops Research Station

Jordan
USAID - American Embassy

Kenya
Coast Workshop for the Handicapped
Egerton College
Kenya Seed Company
Institute for Rural Development
The Dryland Farming Research and Development Project

Korea, Republic of
Horticultural Experiment Station
Hung Nong Seed Company
Kongwon Provincial Office of Rural Development Administration
Korean Advanced Energy Research Institute
Office of Rural Development

Liberia
Central Agricultural Research Institute
Nimba County Rural Development Project

Malawi
Bumbwe Research Station
Lilongwe Agricultural Development Division
Makoka Agricultural Research Station
Smallholder Sugar Authority
Sugar Corporation of Malawi Limited

Malaysia
Agriculture Research Centre
Bayer (Malaysia) Sdn. Bhd.
Malaysian Agricultural Research and Development Institute (MARDI)
Magain Enterprise Sdn. Bhd.
Tropical Industries Sdn. Bhd.
Universiti Pertanian Malaysia

Maldives
Ministry of Agriculture

Mauritius
Ministry of Agriculture, Natural Resources and the Environment Agricultural Services

Mexico
Alimentos del Fuerte

Nepal
Grain Legume Improvement Program
Integrated Cereals Project
Ministry of Agriculture

Netherlands
Enza Zaden de Enkhuizer Zaadhandel B. V.

Nicaragua
Finca La Esperanzita

Nigeria
Ahmadu Bello University
Arbot Farms
Ekiti-Akoko Agricultural Development Project
Lake Chade Research Institute
International Institute of Tropical Agriculture (IITA)
National Horticultural Research Institute
University of Calabar
University of Ibadan
University of Jos

Pakistan
Agricultural Development Bank of Pakistan
Nuclear Institute for Agriculture and Biology
Pakistan Agricultural Research Council

Paraguay
Taiwan Technical Mission

Peru
INIPA - CIPA II
Inter-American Institute for Cooperation on Agriculture
National Food Legume Program
Pyramid Research Center

Philippines
Ateneo de Davao University
AVRDC Philippine Outreach Project
Betinan Research Station
Botanique Philippines Inc.
Bureau of Plant Industry
Cagayan Electric Power and Light Co., Inc.
Don Mariano Marcos Memorial State University

Eden Fruits and Vegetables Co., Inc.
Farm System Development Corporation
Infanta Community Development Administration, Inc.
Institute of Plant Breeding, UPLB
International Potato Center (CIP)
International Rice Research Institute (IRRI)
International Institute of Rural Reconstruction
Isabela State University
Mountain State Agricultural College
National Food and Agricultural Council
Philippines Council for Agricultural and Resources Research and Development (PCARRD)
The Philippine German Seed Potato Program
Philippine Packing Corporation
Philippines Sugar Commission
Sarangani Agricultural Co., Inc.
Second Laguna de Bay Irrigation Project Vegetable Component
University of Southern Mindanao
Victorias Milling Co., Inc.
Visayas State College of Agriculture
Western Luzon Agricultural College

Reunion (France)
IRAT Reunion
Institut de recherches agronomiques tropicales et des cultures vivrieres

Samoa, West
American Samoa Government
Pacific Agricultural Consultancy Service Limited
Peace Corps
Rural Development Section

Saudi Arabia
Ministry of Agriculture and Water
Taiwan Technical Mission

Seychelles
Grand'Anse Experimental Centre

Sierra Leone
Rokupr Rice Research Station
Njala University

Solomon Islands
Ministry of Agriculture and Lands
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Seminars

The following seminars were presented in 1985 by Center staff and guest speakers. Please note that seminar papers are not available for distribution.

January 17 - The Heat Shock Response in Soybean Seedlings: Physiological Considerations, Dr. Chu-yung Lin, Professor, National Taiwan University.

January 23 - Farming Systems Research and Development, Dr. John S. Caldwell, Virginia Polytechnic Institute & State University, USA.

January 31 - AVRDC Computer System, Dr. Jonathan E. Yuen, AVRDC.

February 6 - The Economics of Post Harvest Losses and/or US/Taiwan Trade Relations, Dr. James R. Jones, University of Idaho, USA.

February 14 - The Situation of Processing Tomato Cultivation and its Future Prospect in Korea, Mr. K. K. Lee, Korean Research Intern.

February 14 - Identification of Root Knot Nematode Resistance in Processing Tomatoes by Starch-Gel Electrophoresis and Egg Inoculation Techniques, Mr. H D. Kim, Korean Research Intern.

February 27 - The Extra Floral Nectaries of Cowpea (*Vigna unguiculata* (L.) Walp.); Structure, Nectar Composition and Nectary Functioning, Dr. John Kuo, University of Western Australia.

March 21 - Hormonal Factors in the Fruit Set of Tomato, Dr. George C. Kuo, Plant Physiologist, AVRDC.

March 28 - Plant Regeneration via Embryogenesis in Tissue Culture of Loquat, Dr. Wai-jane Ho, Head of Research Department, Taiwan Seed Improvement and Propagation Station, Taiwan.

April 2 - The Sweet Potato Virus Diseases in Nigeria, Dr. H. W. Rossel, Virologist, IITA, Ibadan, Nigeria, visiting scientist at AVRDC.

April 11 - Studies of the Application of Microbial Nitrogen-fixation in the Local Agriculture, Dr. C. J. Lin, Microbiologist, TARI, Taiwan.

April 25 - Plant Genetic Resources in Ethiopia, Dr. Jan Engels, Project Coordinator & Documentalist, Plant Genetic Resources Center, Ethiopia.

May 3 - Agricultural Systems Analysis and Simulation for Agrotechnology Transfer, Dr. Goro Uehara, Professor, University of Hawaii, USA.

May 9 - Air Pollution Injury to Vegetation in Taiwan, Dr. En-jang Sun, Acting Chief, Bureau of Environmental Protection, DOH, Taiwan.

May 10 - Adaptation of an AVRDC Improved Chinese Cabbage Variety from the Farmer's Perspective in Taiwan, Miss Shu-yu Huang, Principal Research Assistant, AVRDC.

May 16 - Major Constraints in Vegetable Production in the Humid Tropics - with Special Reference to Soil and Crop Management, Dr. Hideo Imai, Soil Scientist, AVRDC.

May 20 - Genetic Resources Among the Wild Tomato Species, Dr. Charles M. Rick, Professor, University of California, Davis, USA.

May 30 - The Low Germinability of Sorghum Seed, the Taichung No. 5, Dr. Wang-ching Ho, AssociateResearch Fellow, Taiwan Seed Improvement and Propagation Station, Taiwan.

June 6 - Control of Papaya Ringspot Virus by Cross Protection, Dr. Shui-dong Yeh, Associate Professor, National Chung Hsing University, Taiwan.

June 13 - Cloning and Expression in *E. coli* of the Whole *Nif* Genes of *Klebsiella oxytoca*, a Nitrogen Fixer in the Rhizosphere of Rice, Dr. Pei-ling Wang, Associate Professor, National Chung Hsing University, Taiwan.

June 20 - Crop Nematode Diseases in Taiwan, Mr. Tung-tsuan Tsay, Teaching Assistant, National Chung Hsing University, Taiwan.

June 27 - Physiology of Short-rooted Mungbean Sprout Cultivation, Dr. Doris C. N. Chang, Professor, National Taiwan University, Taiwan.

June 28 - Vegetable Post Harvest Problems in Asia, Dr. James R. Hicks, Professor, Cornell University, Visiting Scientist at AVRDC.

August 28 - The Caribbean and Agriculture, Dr. Adisak Sajjapongse, Associate Crop Management Specialist, AVRDC.

September 5 - Seedlings and Shelters, Dr. Bernie Kratky, Professor, University of Hawaii, Visiting Scientist at AVRDC.

September 12 - Malathion Detoxication of Diamondback Moth, *Plutella xylostella* L., Dr. William C. J. Maa, Research Fellow, Academia Sinica, Taiwan.

September 19 - Chinese Cabbage Germplasm at AVRDC, Dr. Chong-seng Tay, Seed Technologist, AVRDC.

September 26 - Residue and Toxicity Problems Associated with Pesticide Use in Taiwan, Dr. Gwo-chen Li, Director, Taiwan Agricultural Chemical & Toxic Substances Research Institute, Taiwan.

September 26 - My Vegetable Research Experience, Prof. D. H. Dabbs, Department of Horticultural Science, University of Saskatchewan, Canada.

September 26 - The Louisiana Foundation Seed Production for Sweet Potatoes, Dr. Ron Robbins, Resident Director, Sweet Potato Research Station, Louisiana State University, USA.

September 26 - Production of Vegetable Seeds in the United States, Dr. Charles W. Reynolds, Professor, Department of Horticulture, University of Maryland, College Park, USA.

September 26 - Variety Trials of Vegetable Crops in the Tropical Lowlands of Honduras, Central America, Dr. Le Da Ton, Horticulturist, United Fruit Company, Port Newark, New Jersey, USA.

October 3 - Breeding for Rice Blast Resistance in Taiwan, Mr. Hsin-kan Wu, Research Fellow, Academia Sinica, Taiwan.

October 16 - Major Diseases of Asparagus and their Control in Taiwan, Dr. Yung-hsiung Cheng, Chief, Division of Crops Environment, District Agricultural Improvement Station, Taiwan.

October 24 - Application of Monoclonal Antibodies to Research on Plant Virus and Virus-like Diseases, Dr. Hong-ji Su, Professor, National Taiwan University.

October 28 - Application of Protein Electrophoresis for Evaluation of Cultivated Plants, Dr. H. Stegemann, Institute for Biochemistry, Federal Institute of Biology, Federal Republic of Germany.

November 7 - Under-exploited Vegetable Crop - Edible Amaranth, Dr. Huang Han, Professor, National Taiwan University.

November 14 - Potato Breeding by Ploid Manipulations Using Haploids and 2n Gametes, Dr. Masaru Iwanaga, Cytogeneticist, CIP, Visiting Scientist at AVRDC.

November 28 - The Potential of Plant Virus Control of Genetic Engineering, Dr. Yau-heiu Hsu, Associate Professor, National Chung Hsing University, Taiwan.

Finances

AVRDC's projected budget for 1985 was US$4,950,000, compared with an actual income of US$4,905,901 and expenditures of US$4,518,249. Core funding was provided by the governments of Republic of China, the United States, the Philippines, the Republic of Korea, Japan, Thailand, and the Federal Republic of Germany.

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International Board for Plant Genetic Resources
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National Science Council (ROC)
International Soybean Program (INTSOY)
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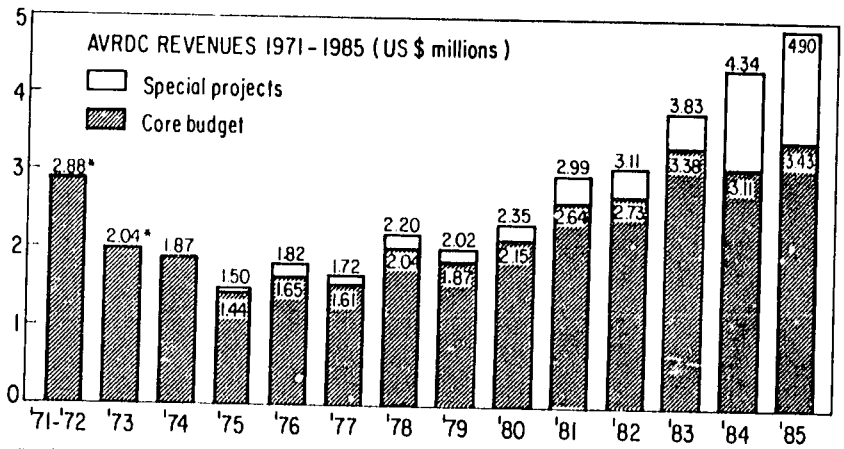
Taiwan Kagome Co.
Campbell Soup Company
Nagasaki Farmers Cooperative
Potash and Phosphate Institute of Canada



*US $ 3.4 million for capital expenditures 1971-73