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9. ABSTRACT

Summarizes research, training, and outreach activities conducted in 1977 by the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. The text is prefaced by a brief commentary on AVRDC's overall research activities. Next, short individual reports on research conducted by AVRDC in 1977 on tomatoes, Chinese cabbage, white potatoe, sweet potato, mungbean, and soybean are provided. Research objectives are outlined for each crop, and experiments on yield, heat tolerance, disease and insect resistance, productivity, and germplasm improvement are discussed and illustrated with numerous tables, diagrams, and photographs. The concluding chapters summarize results of research to improve crop environment, farm management, marketing techniques, and nutritional content of vegetable crops, and review AVRDC's outreach programs.

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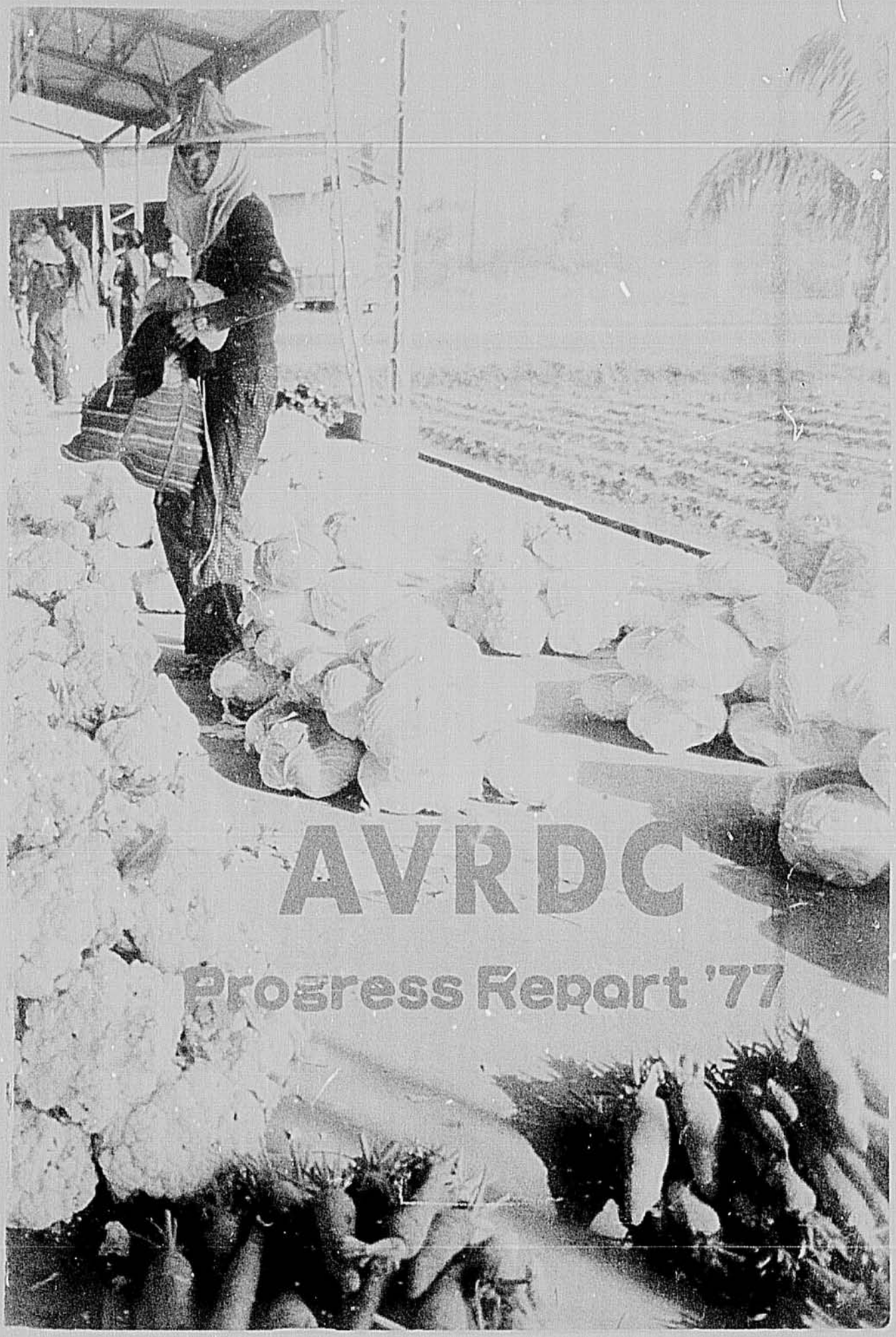

AVRDC

Progress Report '77

ERRATA

p2. Correct citation: Asian Vegetable Research and Development Center. 1978. Progress Report for 1977. Shanhua, Taiwan, Republic of China.

9. Picture caption "above". ...Port Moresby in 1977. One trial averaged....

10. Gains Against Tropical Production Constraints

Table 3[a]. ... of 2 trials were homogeneous...

13. Table 4. Effect of aqueous stigma exudate on tomato pollen germination and growth; 1977, AVRDC[a].

15. Picture caption. ...wiped out by bacterial wilt like the local variety at lower left.

21. Table 2. Yield and other horticultural characteristics of promising hybrid combinations between matromorph S_2 lines with self-incompatiblity; 1977, AVRDC.

22, para 1, line 3. ...(Nabyeng 60 days F_1)...

3, line 2. ...bacterial soft rot or downy mildew were screened along with a susceptible check for multiple resistance to bacterial soft rot, downy mildew, and TuMV.

26. Picture caption. ...1977 segregating populations...

30. Fig. 3. Diseased plantlets from the same meristem destroyed

para 2, line 3. ...60 kg/ha N.
6. ..120 kg/ha N.

37, para 1, line 1. ...30 kg/ha N, 60 kg/ha P, and 90 kg/ha K.
3. ...30 kg/ha N and 45 kg/ha K.

47, para 3. Both Daconil 75 W at 2.5 kg/ha and Milcurb-super 25% E.C. at 0.75 ℓ/ha effectively controlled powdery mildew.

50. Table 2. Photorespiration of mungbean and other crops. Release of $^{14}CO_2$ measured from leaf discs supplied with glycolate -1-^{14}C in light; 1977, AVRDC[a].

51. Table 3. Photorespiration of selected mungbean cultivars, as indicated by the rate of release of $^{14}CO_2$ from mungbean leaf discs supplied glycolate-1-^{14}C in light; 1977, AVRDC[a].

66, para 2, line 7. ... water potentials higher than -0.4 bar...

68. Fig. 4. Persistence of different insecticides during 3 years.

75, para 3, line 4. ... Visayas Experiment Station...

80, para 2, line 4. ... (duplicates included).
4, line 3. data. The major tool used for statistical analysis and for creating...
8. ... International Mungbean Nursery (IMN)...

83. Table 1, last item. CEC (meq/100 g)

88, para 2, line last. ...National Chung Hsing University.

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About this report

AVRDC is the international agricultural research and training organization responsible for improving the production and quality of selected vegetable and legume crops in the humid tropics.

The 1977 Progress Report summarizes research, training, and outreach activities conducted by the Asian Vegetable Research and Development Center (AVRDC). For those interested in more detailed accounts of individual studies, research reports are being published on each crop. These reports and other technical papers may be obtained by writing the Office of Information Services at AVRDC. Please be sure to give your complete mailing address. Scientists in other countries are also urged to correspond with AVRDC's investigators regarding technical points and problems.

Data are presented in metric units. Monetary values have been converted to equivalent U.S. dollars. "Check" means an untreated experimental plot unless stated otherwise. A single asterisk (*) means significant at the 5% level; a double asterisk (**) means significant at the 1% level. Pedigrees in the AVRDC breeding program are identified by a slant bar (/). Commercial chemical names are occasionally used for identification; such use does not imply an endorsement by AVRDC.

Information and conclusions reported herein are solely the responsibility of AVRDC. A financial summary for the Center's 1977 activities is on page 88.

Correct citation: Asian Vegetable Research and Development Center. 1977. Progress for 1977. Shanhua, Taiwan, Republic of China.

AVRDC P. O. Box 42
Shanhua, Tainan 741
Taiwan, R. O. C.

Director's Foreword

This has been another active and productive year of research and training for AVRDC.

The first International Symposium on Mungbean was held in the Philippines in August. Participants representing 45 organizations in 16 countries reviewed mungbean research and production. The soybean rust working group met for the first time since its formation in Chiang Mai in 1976 to sharpen the attack on this disease. Our research effort is being coordinated with INTSOY and the USDA.

The tropical tomato became a reality as more and more Asian countries conducted trials in the hot humid lowlands with AVRDC breeding lines. Heat tolerant white potato clones again demonstrated a high yield potential at sea level trials in Mindanao, Philippines. However, virus free potato seed production in the tropics is now the major barrier to extensive planting by farmers. Our promising materials have been given to the International Potato Center (CIP), which is devoting its resources toward solving this problem.

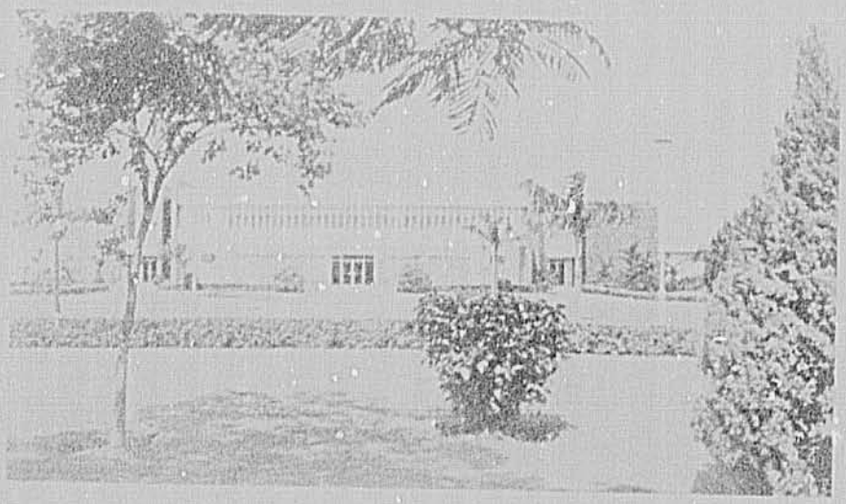
Sweet potato again proved to be a staple source of calories and vitamins in minimum input trials in Bangladesh as well as on flooded plots on AVRDC's experimental farm during the monsoon season. It was the only crop out of six which was not devastated by five exceptionally severe tropical storms experienced this year in Taiwan. Thousands of man-hours of research and labor were lost as the result of the five storms. Chinese cabbage summer yield trials were destroyed by the flooding but seed distribution to cooperators was greatly increased.

The Korean Outreach Program became fully operational, and the Philippine Outreach Program was totally integrated into their national agricultural research network.

Dwindling financial resources persist in being our most serious problem. Increased private support has compensated in part to maintaining an active research and training program. We seek additional help from individuals or organizations interested in supporting our efforts to provide more nutritous food for mankind. We have been able to report continuous progress in our mission due to the hard work and dedication of our scientific, technical, and support staff. We are, however, approaching a point where further loss of international support threatens the operation of the Center.

James C. Moomaw
Director

The Asian Vegetable Research and Development Center Progress Report for 1977



Tomato

Objectives

- Greater yields under the humid conditions of the lowland tropics.
- Varietal resistance to bacterial wilt, tomato mosaic virus, late blight and other tropical diseases.
- Increased size and quality of tomatoes produced during the hot season for both the fresh market and processing.
- Development of management practices to permit genetically improved cultivars to flourish under tropical lowland conditions.

Newly developed AVRDC lines performed well under cultivation, heat, and humidity of the lowland tropics in Asia & Pacific Islands.

Germplasm Collection Reaches 4,703

In 1977, we received 629 new accessions from various sources, including 552 from the U.S. Department of Agriculture's South American Collection. This brought our total germplasm accessions to 4,703. We supplied 1,529 seed packets of elite breeding lines to scientists in more than 40 countries. More than 2,000 seed packets of other AVRDC materials were distributed throughout the tropical areas of South America, Africa, Asia, and Pacific Islands.

Lines Perform Well in Southeast Asia

Our breeding lines continued to demonstrate superiority over the local cultivars in tests in many Southeast Asian countries. The Malaysian Agricultural Research and Development Institute (MARDI) featured several AVRDC-derived lines in a field day July 12. These lines demonstrated wilt resistance while check cultivars Roma and Banting were completely wiped out by wilt (Table 1).

Equally encouraging reports came from three reporting stations in the Philippines: Ilocos Sur, in the north; Laguna, in the central region; and Davao, in the south (Table 2).

Agronomists at the Laloki Plant Introduction and Horticultural Research Station in Papua New Guinea selected AVRDC's 555 F_5-19 on the basis of its disease tolerance, palatability, and fruit size for use in commerical trials. Selection 555 F_5-19 yielded 39 and 48 t/ha in the first and second pilot trials near Port Moresby.

Table 1. The yield, fruit size, days to flowering and survival rate of the best breeding lines in an advanced yield trial, 1977, Jalan Kebun Experiment Station, MARDI, Malaysia.

SSD no.	Marketable yield		Fruit size	Survival rate	
				Actual	Transformed
	(kg/plot)	(t/ha)	(g)	(%)	(arcsine)
502 F_4-20	7.87	25	34	52	46
507 F_4-14	6.96	22	51	72	58
502 F_4-34	5.90	19	50	67	60
502 F_4-39	5.05	16	36	48	44
507 F_4-34	5.05	16	43	52	46
507 F_4- 6	4.84	16	30	50	45
507 F_4-44	4.78	15	35	42	41
LSD 0.05	2.94		12		ns
0.01	3.96		17		--
C.V. %	40		19		12

[1]Planted May 5; and 7 harvestings beginning July 9 ending Aug 8; data are means of 3 replications. [2]Under natural epiphytotic of *F. solanacearum*; Banting, the check cultivar was completely wiped out by disease; data transformed to arcsine before analysis of variance was made.

Table 2. Yields of AVRDC breeding lines in trials conducted in 3 locations, 1977; Philippines[1]

AVRDC selection no.	Marketable yield
	(t/ha)
Vigan, Ilocos Sur[2]	
32d-0-0-1-1-0	63
8d-0-7-1-0	60
11d-0-1-2-0-0	46
7-0-10-1-0-0	44
170-0-2B-2-0-0	37
Economic Garden, Los Baños, Laguna[3]	
8d-0-7-1-0	51
32d-0-1-15-0	49
32d-0-1-4-0	45
32d-0-1-25-0	43
32d-0-1-13-0	43
Improved Pope (check)	22
Twin Rivers Research Center, Madaum, Davao[3]	
11d-0-1-2-0-0	27
8d-0-7-1-0-0	25
170-3-1-0	16
32d-0-1-19-0-0	17
143-0-6-9-0	17
Improved Pope (check)	9

[1]Planted Oct. 4, 1976; 5 harvestings beginning Jan. 3 ending Jan 21; means of 3 replications. [2]Planted Mar. 18; 18 harvestings beginning May 6 ending June 30; means of 4 replications. [3]Planted Apr. 6; 6 harvestings beginning June. 6 ending Jul. 5; means of 2 replications.

Gains Against Tropic Production Constraints

We conducted several trials at AVRDC which demonstrated the potential of our lines for summer production in wilt infested areas (Table 3) All the breeding lines outyielded the susceptible check, White Skin, because of higher fruit setting and more resistance to bacterial wilt. Only 4 lines outyielded VC 48-1, resistant check. All other selections not included in Table 3 yielded at least 19 t/ha and compared favorably with VC 48-1. Some of the selections had comparable fruit size to White Skin. We found the fruit of most selections were more acidic (sour) than White Skin, which will deter their acceptance under local conditions. They are, however, comparable in eating quality with the local cultivars in other southeast Asian countries where tomatoes are used as a vegetable and not as a fruit. For this use, the higher acid will not be objectionable.

We investigated response to moisture of three tomato cultivars: Nagcarlan (heat-tolerant), LA 1421 (moisture-tolerant), and White-Skin (neither moisture nor heat tolerant). In this study, simulated rain, using sprinklers, reduced the root and top dry matter, fruit-setting rate, and score in all cultivars (Figs. 1 and 2). The degree of reduction was magnified when the drainage was poor (resulting in flooding). The root growth and fruit setting of Nagcarlan and LA 1421 were not as seriously affected by excess water or poor drainage as that of White Skin.

Table 3. The yield and fruit size of best breeding lines in two summer trials; 1977, AVRDC[1].

Entry selection no.	Marketable yield Trial I	Marketable yield Trial II	Average fruit size
	(t/ha)		(g)
8d-0-7-1-0-0-0	23	50	56
143-0-10-3-0	22	44	40
9d-0-3-6-0-0-0	17	52	54
119-1-2-0	29	29	36
9-0-0-1-0-0	15	44	48
143-0-48-1-0-0-0	22	34	35
123-2-4-0-0	10	44	48
143-0-6-9-0-0-0	11	36	18
VC-48-1 Heat tolerant & bacterial wilt resistant check	17	32	58
White Skin Heat sensitive & bacterial wilt susceptible check	0.6	18	53
LSD .05	9	9	5
.01	11	12	7
C.V.	44	22	15

[1]Planted Aug. 16 and 30 for Trial I & II, respectively; Trial I, 3 harvestings (Nov. 1, 11, and 23); Trial II, 4 harvestings (Nov. 11, 23, 30, and Dec. 8); combined analysis of variance was carried out for fruit size since variances of 2 trials were homogenious as shown by Bartlets test.

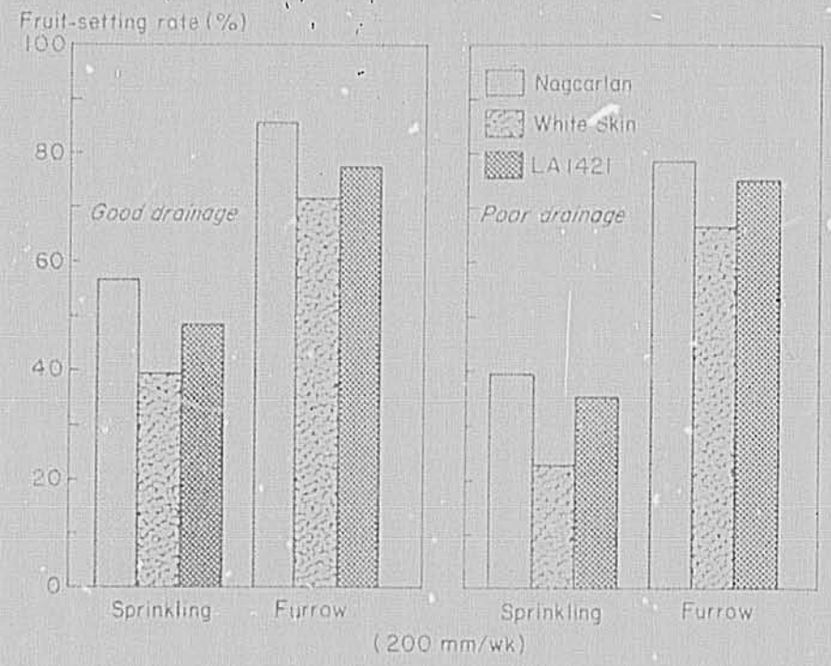


Fig. 1. Effects of simulated rainfall (sprinkler), furrow irrigation, and drainage on fruitsetting rate of three tomato cultivars.

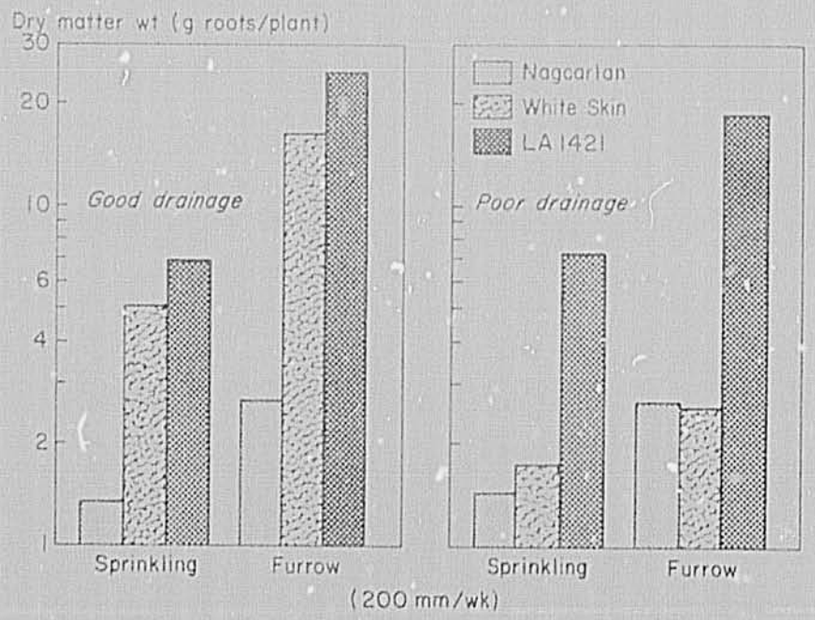


Fig. 2. Effect of simulated rainfall (sprinkler), furrow irrigation, and drainage on dry matter of roots of three tomato cultivars.

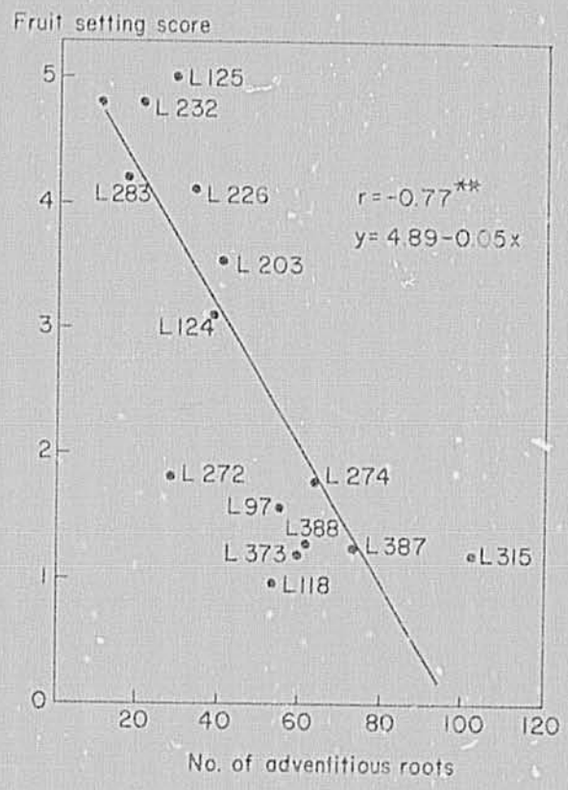


Fig. 3. Relationship of tomato fruit setting score and number of adventitious roots induced by application of ethrel. Fruit setting score is field rating of 1 (poor) to 5 (heavy).

New Aids for Heat Tolerance Screening

Our physiologists found cultivar differences in the number of adventitious roots formed due to ethrel application (3000 mg/1). The number of roots was inversely related to fruit setting scores (Fig. 3). This discovery should provide a useful technique for screening for heat tolerance. The Center's plant breeders confirmed previous findings that growing tomato seedlings in 14-cm pots outside the greenhouse and scoring them for heat tolerance could also be used as a method for screening heat tolerance in the tomato where field testing is prohibitive.

Physiology of Heat Tolerance Investigated

Our physiologists conducted experiments to further clarify the physiology of heat tolerance in tomato. They found that high day (38°C) and high night (25°C) temperatures had equally depressing effect on fruit set. The high temperatures affected pollen germination and pollen tube growth in both 123 (heat sensitive) and 125 (heat tolerant) accessions. Development of microspores (pollen) was more sensitive to high temperature injury in 123 than in 125.

The stigma exudate from 226, another heat tolerant accession, appeared to have promotive effect on pollen germination and pollen tube growth when applied to both heat tolerant and heat sensitive accessions (Table 4). Abscission of reproductive organs appeared to be under hormonal control. IAA prevented pedicel abscission of both heat tolerant and heat sensitive accessions, whereas, ethrel induced abscission in both.

Table 4. Effect of aqueous stigma exudate on tomato pollen germination and growth.

Pollen source	Acc. 95 (HS)			Acc. 226 (HT)			
Exudate source	Acc. 95 (HS)	Control	Acc. 26 (HT)	Acc. 95 (HS)	Control	Acc. 226 (HT)	LSD .05
Pollen germination (%)	31	8	44	2	10	41	5
Pollen tube length (μ)	68	42	183	50	75	170	12

Mean maximum temperature 10 days before pollen collection was 31°C, and pollen was incubated at 28°C for 1 hr. for the test.
HS=heat sensitive HT=heat tolerant Control 20% sucrose + 100 ppm H_3BO_3
Treatments 20% Sucrose + 100 ppm H_3BO_3 + 5:1gm Exudate from Acc. indicated.

Root-Knot Nematode Nursery Started

Our plant pathologist established a root-knot nematode nursery at AVRDC. Susceptible cultivars had up to 100 galls per plant, which indicates that nematode infestation is adequate to effectively screen for varietal resistance. Through differential host test, we also indentified the prevalent species of root-knot nematodes at AVRDC to be *Meloidogyne incognita*.

New Approach to Bacterial Wilt Screening

We investigated a new approach of screening for bacterial wilt resistance in the greenhouse. Two-week old seedlings were inoculated 3 times at 5-day intervals with 10^5 bacterial cells per ml using the stem puncture method. Surviving plants were transplanted in 12-inch pots, their seeds were collected for further tests. One survivor of VC 49-1-5 after 3 screening cycles was planted in the bacterial wilt nursery with several other accessions. Results indicated that resistance to bacterial wilt can be increased by this screening method (Fig. 4). For example, VC 49-1-5-S2 was more resistant than the original VC 49-1-5.

SSD and Hybridization Results Encouraging

The use of single seed descent (SSD) proved to be an effective method of advancing generations of segregating populations and selecting desirable genotypes that best suited local country conditions. Outstand-

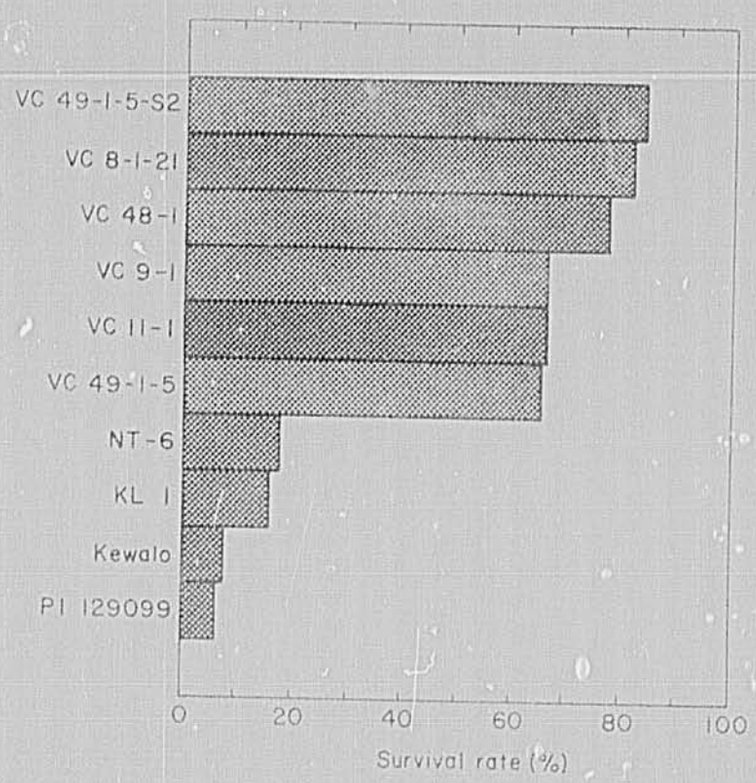


Fig. 4. Reaction of 10 tomato cultivars to bacterial wilt, *Pseudomonas solanacearum*, in an inoculated field trial, 1977, AVRDC. Eighty plants per replication, 5 replications, all plants inoculated 3 times with pathogenic solution of 10^8 cells/ml. Fourth inoculation with pathogen concentrate of 10^{11} cells/ml.

ing selections in Papua New Guinea and Malaysia come from SSD materials. Selections from a given cross differ from country to country, primarily because of varied environmental conditions. Performance of SSD materials in Bangladesh is shown in Table 5.

We had good results from breeding lines and F_1 combinations in our late winter evaluation. Yields of F_1 combinations were particularly encouraging. With only two harvestings, we obtained yields as high as 79 t/ha from Kewalo/Pelatte (Table 6), which was about 35 t higher than the yield of selection 156-6-3-0, the highest yielding breeding line in another trial.

We conducted one fresh market yield trial of some AVRDC F_1 combinations. Five combinations outyielded Green Skin, the check variety, by 93 to 260%. We thus demonstrated again that there are suitable breeding lines which can be grown in late winter to lengthen the tomato season. We feel that these lines, plus an appropriate management practice could prolong the tomato season in Taiwan by at least 1.5 months.

Survey Summer Tomato Production in Taiwan

Our economists conducted a survey of 109 producers and collected tomato production and meteorological data during the summer in Taiwan.

Table 5. Yields and fruit size of [illegible] SSD lines from VC 8-1-2-1/Venus//Kewalo in preliminary trial, 1977, Bangladesh.

SSD no.	Marketable yield (t/ha)	Fruit size (g)
16	31	73
18	39	71
39	28	94
3	28	62
40	25	53
38	24	84

[1]Data submitted by Vegetable Central Committee, Bangladesh; planted Nov. 30 (13/6), 6 harvestings beginning Mar. 2 ending Apr. 3; means of 3 replications.

Table 6. Yield performance and processing characteristics of F_1 hybrid lines produced at AVRDC, 1977, AVRDC[1].

AVRDC selection (or acc. no.)	Pedigree or (cultivar name)	Marketable yield (t/ha)	Fruit size (g)	Total solids (°Brix)
1446	Kewalo/Pelatte	79	54	4.72
1447	Tamu Chico III/VC 9-1-2-9B/Venus	76	52	5.56
1442	Kewalo/PI 289236	62	52	4.60
1503	F-63-27/Pelatte	56	64	4.49
1403	VC 8-1-2-0/CAL-5	51	60	4.43
(4018)	Lucky (F1 check) (locally produced F_1 hybrid)	57	41	5.04
(3975)	TK-70 (Processing check) (commercial processing cultivar in Taiwan)	39	56	5.20
LSD .05		25	12	0.94
C.V. (%)		30	17	9

[1]Planted Feb. 3; 2 harvestings May 4 and 17; all values are means of 2 replications. No significant difference between titratable acid, pH, or color.
Total number of entries 45

Field day in Malaysia featured selections from new AVRDC wilt resistant lines (right). Formerly tomatoes had to be grafted to eggplant root stock to keep them from being wiped out by bacterial wilt like the local variety at center.

We defined the varying crop seasons as late summer, lasting from the beginning of August to late December in Changhua district (lowland); early summer, lasting from the beginning of April to late July in Taipei district (highland); and summer, lasting from middle May to early September in Nantou district (highland). In each of these seasons and districts tomatoes are adversely affected by high temperature and/or excessive rainfall during at least part of their criticial growth stage.

From our survey we arrived at the following conclusions:

1. Heat tolerance is the major selection criteria for lowland producers, but product appearance and higher yield are important to highland producers.

2. Seasonal temperature patterns are a key determinant to fruit set, growth period, and hence yield. Similarly, rainfall patterns are different for each of the three samples. Both factors explain why the late summer crop has the highest yields.

3. Plant height and number of clusters per plant depend on the growth duration only in the late summer sample. For the other two seasons, rising temperature curtails the number of clusters set. In no sample was the correlation between crop density and yield significant. However, a higher yield from 2-stem crops with lower crop density in Taipei suggests this technique could be extended to other highland environments.

4. Summer tomato is attacked by virus disease, bacterial wilt, gray leaf spot, leaf molds, and blotchy ripening. Insect damage is slight.

5. Soil suitability, drainage, adequacy of irrigation, and typhoon damage all affected yield, regardless of seasonal sub-sample.

6. Late summer tomato dominates in terms of yield but ranks last in total and net revenue because of low price.

7. Net return and farm income can be promoted by reducing production cost of hormone treatment, fertilization, and total preharvest cost, and by elevating yield. In Changhua and Nantou, cost reduction is more efficient, and in Taipei, yield improvement is more important in attaining high net returns.

8. Yield improvement, however, does not depend significantly on the level of management costs.

9 Summer tomato is the most profitable among all seasons and types of tomato production and compared with its major competing crop, rice (Table 7).

Conclusion from Summer Management Trials

We also conducted a late summer tomato management trial at AVRDC. Of all possible production combinations, planting 11d-0-1-2-0 on silt loam with 20 t/ha of rice straw compost and 53 gm of benzyladenine (BA)

Table 7. Comparison of production factors among summer tomato, non-summer tomato and rice in Taiwan, 1976-77.

Crop	Summer tomato N=109	Winter fresh-market tomato	Winter processing tomato N=10	Rice
Field kg/ha	49,946	48,452	32,471	4,269
Price US$/ton	175	95	29	302
Revenue US$	8,722	4,608	954	1,431
Expenses US$	8,039	4,372	827	1,248
Capital	3,016	1,546	369	744
Labor	5,023	2,826	458	504
Net return US$	683	236	127	183
Farm income US$	5,769	3,174	372	817

Source: Survey data, 1977.
Reports on Agricultural Products' Production Costs by PDAF, 1977.
Statistics from AVRDC Farming Practice Research, 1977.

per ha, without excessive irrigation, gave both the highest yield (57 t/ha) and the highest net profit (US$5,612/ha). Compost had a favorable impact on yield and profit under all management combinations, but applications of hormones reduced net profit for both cultivars on sandy loam, and decreased yield from White Skin on sandy loam.

We continued to evaluate data on tomato production from 18 daily record-keeping households in one irrigated and one upland village near AVRDC. We arrived at the following conclusions:

1. The higher the yield the higher the net return. For every one-ton increase in yield, the farmer can expect to earn an additional US$44/ha.

2. The higher the inputs of total labor, the higher the agronomic yield and net return. For every additional 8 hrs. of labor input, yield increased 179 kg and net return, US$4.83/ha.

3. An acceptable agronomic yield is also acceptable economically. The agronomically acceptable yield per plant under local monocropped conditions is 3.13 kg, while the current break-even point economically is only 2.05 kg per plant. Farmers average less than the agronomic objective, but they are still making a profit.

4. Highest yields are achieved under a monoculture tillage method. The results led us to reject the following hypotheses:

   a. The higher the investment in total material costs the higher the yield. This is true only in the rice-stubble method.

   b. The greater the investments in fertilizer, the higher the yield.

Chinese Cabbage

Objectives

* Development of heat tolerant varieties with higher yields during the hot, wet season in the lowland tropics.

* Identification of disease and insect resistance for incorporation into improved varieties.

* Development of insect pest controls that do not leave residues.

Gains being made in head size, firmness, yield, and disease and insect resistance.

Surveys Confirm High Fertilizer Requirement

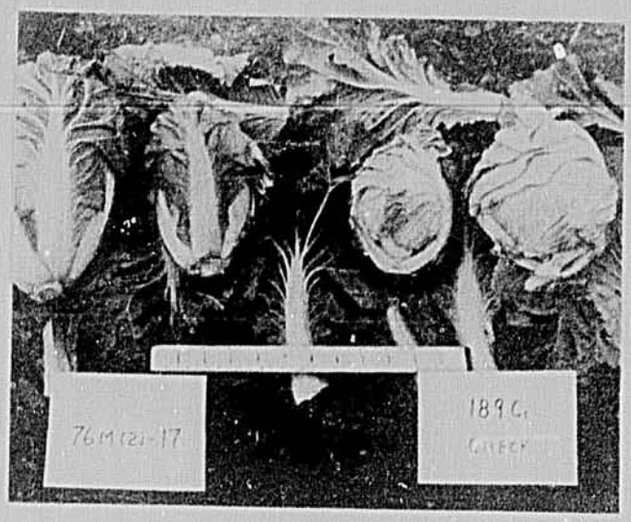
From comparative farm survey studies our economists confirmed Chinese cabbage as being an input intensive crop. It has especially high fertilizer requirements. Labor for cultivation and weeding is also an important input in determining the high yield and success of the crop.

Germplasm Evaluation and Improvement

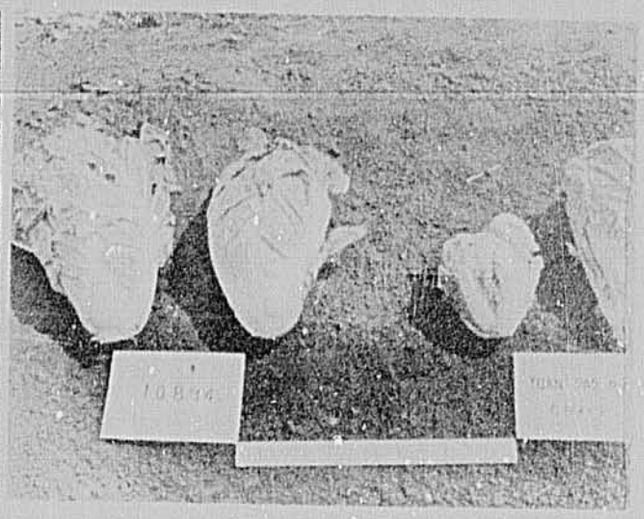
Eighteen new accessions were added to the germplasm collection in 1977, bringing the total to 658. We have tentatively indentified 9 of the new accessions as heat tolerant, thus increasing the total to 78, or 15.6% of our *Brassica pekinensis* collection.

We continued to screen segregating populations and advanced lines for heat tolerance and resistance to major diseases. More than 45,000 individual plants were screened but less than 2000 were selected for further evaluation, giving an average selection percentage of approximately 4.4%.

A significant 8% yield gain was obtained from an additional cycle of recurrent selection in population 129. The predicted gain in head weight (31 g) closely approximated the actual gain (37 g).



One of the highest producing open pollinated accessions compared with check.



One of the highest producing F_1 varieties compared with popular check variety.

Head Size Increased

Population 152 responded significantly to a cycle of mass selection for large head, the gain amounting to 20% of the yield of the source cultivar.

In a summer yield trial of new, open-pollinated populations developed from the breeding program, all new entries significantly outyielded the improved open-pollinated check, 189 C_1 (11). Most entries had higher yields than the F_1 hybrid check, Yuan Pao No. 2 (acc 644), and the other improved open-pollinated check, 129 C_1 (11). However, only one entry, 76 M (1)-4, significantly outyielded the check varieties (Table 1).

Promising New F_1 Hybrids

Eight experimental F_1 hybrid combinations between inbred lines carrying self-incompatibility genes were identified as superior in many respects to Yuan Pao No. 2 (acc 644), a hybrid that is becoming increasingly popular in Taiwan. The highest yield obtained was 57 t/ha in 49 days. Some combinations that did not outyield acc 644, matured one week earlier (Table 2).

We concluded maternals derived from pseudogamy were highly heterozygous, based on a single gene marker test, as well as comparisons of within-plot variances between S_1 progenies of maternals and conventional inbred lines derived from common families. Thus, pseudogamy is not a feasible breeding tool to derive homozygous inbred lines in a short time.

Downy Mildew and TuMV Resistance

Twenty-one accessions which had been indentified as resistant to downy mildew, and 26 new accessions were screened for resistance to this pathogen (*Peronospora parasitica*) in the spring. Only acc 304 (Mei-Lu) showed resistance. All the entries that were rated resistant in fall of 1976 became susceptible, apparently due to severity of the disease under relatively higher temperature. The fall, then, is the best time to screen for downy mildew resistance at AVRDC.

Table 1. Yield and horticultural characteristics of open-pollinated materials derived from intercrosses of selected inbred lines, 1977 Summer, AVRDC.

Entry	Yield	Marketable head weight	Maturity[1]	Production rate	Total vegetative top growth	Heading rate
	(t/ha)	(g)	(da)	(kg/ha/da)	(g)	(%)
76 M(1)-4	35.3	897	51	690	1489	92
76 M(2)-17	32.5	826	50	650	1362	100
76 M(2)-20	31.8	718	50	630	1266	98
76 M(2)-11	28.9	698	50	580	1282	88
76 M(2)-18	26.2	566	51	510	940	89
76 M(2)-16	24.6	600	50	490	1003	100
Check entries:						
Yuan Pao #2	24.4	491	47	520	824	97
129 C_1(11)	23.6	565	50	470	1009	86
189 C_1(11)	14.7	325	42	350	569	98
HSD (5%)	9.9	331	8	-	777	-
CV (%)	12.7	16.2	5.4	-	21.2	-

[1]Determined from transplanting to 50% plot harvest date. Planted August 3, 1977.

Table 2. Yield and other horticultural characteristics of promising hybrid combinations between patriomorph S₁ lines with self-incompatibility.

Combination	Estimated yield	Head weight	Maturity	Vegetative growth	Heading efficiency	Heading rate
	(t/ha)	(g)	(days)	(g)		(%)
7372-3-2/7319-3M	56.9	1279	49	1724	1.2	75
7252-4-3/7322-2M	50.0	1125	46	1990	1.5	100
7252-4-5/7322-2M	46.7	1050	46	1800	1.8	100
7252-1-2/7322-2M	44.0	990	36	1675	2.0	100
7406-2-4/7252-1M	42.8	962	40	1753	1.3	100
7252-4-3/7307-2M	41.4	932	40	1453	1.8	100
7252-1-2/7307-2M	38.8	874	36	1560	1.4	100
7252-4-5/7307-2M	33.9	763	36	1136	1.4	100
Yuan Pao -2 (ck)	33.1	744	43	1290	1.7	100

[1]Transplanting to 50% plot harvest date. [2]Ratio of head weight to weight of nonwrapper (NW) leaves. Planted September 2, 1977.

During spring and fall, we surveyed 34 accessions which had been rated as resistant to turnip mosaic virus (TuMV), in field and greenhouse tests. AVRDC accessions 204 (Nabyeng 60 daus F_1) and 205 (Konong $3F_1$) were consistently resistant in four screenings. Accessions 64 (Tip Top No. 12 F_1) and 141 (Ta-Feng Feng Lu) were resistant in the fall screening (Table 3). This concludes our search for sources of resistance to TuMV. There are sufficiently strong sources of resistance to TuMV for breeders to use in our crop improvement program.

Table 3. Reaction of 10 *Brassica pekinensis* lines to Turnip Mosaic Virus, 1977, AVRDC.

Acc. No.	Spring[a]		Fall	
	field	G.H.	field	G.H.
Heat sensitive cultivars				
204 F_1	R	R[b]	R	R[b]
205 F_1	R	R	R	R
507 IB	MR	R	MR	R
516 IB	MR	R	MR	MR
25 F_1	S	R	MR	S
Heat tolerant cultivars				
598 OP	MR	R	S	S
41 OP	MR	MR	S	S
594 OP	S	R	S	S
595 OP	S	R	S	S
151 F_1	S	R	S	S

[a]R = Resistant < 10% infection. MR = Moderately resistant 11-40% infection. S = Susceptible > 40% infection. [b]Resistance confirmed by back inoculation to *Chenopodium amaranticolor*. F_1 = F_1 line. OP = Open-pollinated line. IB = Inbred line.

Two Resistant to Soft Rot

Fifty-seven accessions identified as resistant to bacterial soft rot (*Erwinia carotovora*) were further screened along with 16 new accessions supposedly resistant to the same disease. Accessions 221 (Baechu) and 637 (Seoul-207) remained resistant.

Three Accessions Show Multiple Resistance

Twelve accessions which were rated as either resistant or moderately resistant to bacterial soft or downy mildew were screened along with a susceptible check for multiple resistance to bacterial soft rot, downy mildew, and (TuMV). Three accessions, 18 (Uji hybrid F_1), 204 (Nabyeng 60 days F_1), and 310 (Korean hybrid 6) had multiple resistance to all three diseases. They will be tested further for confirmation of these traits.

Four Accessions Indicate Tolerance to Aphids

In our entomological host-plant resistance work we screened 86 accessions of Chinese cabbage (non-heading type) and related species for resistance against aphids (*Rhopalosiphum pseudobrassicae* and *Myzus per-*

Fig. 1. Chromatograph of leaf surface waxes of aphid tolerant and susceptible *Brassica* accessions.

sicae). During insect counts made a month later, after transplanting, we found all but four accessions wiped out, largely due to aphids. The accessions (464, 487, 488, and 490) that survived appeared to be tolerant, as they too had heavy aphid infestation, but were still healthy. These same accessions were also least damaged by striped flea beetle (*Phyllotreta striolata*) in another test.

The aphid tolerant accessions belong to the *Brassica juncea* species. Interspecific crosses between *B. pekinensis* and *B. juncea* can be made, so it is possible that this trait can be incorporated into the heading type of Chinese cabbage. The leaves of the tolerant accessions are thicker and smoother than the leaves of susceptible ones. Preliminary chemical analysis reveals they have higher concentrations of long carbon chain waxes in their leaf culticles (Fig. 1).

Chemical Control Tested

During the second half of 1977 we conducted two insecticide screening trials for insect pest control. Tokuthion, Decis, S-3151, and Orthene gave effective control of aphids and diamondback moth (Table 4). Insecticide treatment that gave significant control also gave increased yield.

Table 4. Most effective insecticides for control of diamondback moth and aphids, 1977, AVRDC.

Chemical	Application rate	Moth larve pupae	Heads with > 1000 aphids	Yield
	(g a.i./ha)[1]	(no./10 plants)	(%)	(t/ha)
Tokuthion 50% EC	1,000	0.0	0.0	30.3
Decis 2.5% EC	100	0.0	1.3	27.3
Decis 2.5% EC	25	0.0	3.8	21.1
Decis 2.5% EC	50	0.0	0.3	18.9
S-3151 20% EC	100	0.0	6.9	18.4
Orthene 25% EC	500	2.9	5.0	17.4
Check	-	27.8	62.0	0.0

a.i. = active ingredients. Transplanted to field Oct. 4. Harvested Dec. 28. Five weekly sprayings. Diamond back moth data are average of 3 observations. Aphid data are average of 8 observations each on 10 plants.

Leaf Area Didn't Affect Heat Tolerance

We carried out growth analytical studies of heat tolerant and heat sensitive accessions in three seasons, and found that leaf area and leaf number were not important in determining heat tolerance or head formation. Leaf area was highly correlated with leaf fresh or dry weight in different planting seasons.

Gibberellin Promotes Flowering - Replaces need for vernalization

Both heat tolerant and heat sensitive varieties required low temperature and longer photoperiod to get plants to bolt and flower, although longest vernalizing period was required for heat sensitive varieties. Gibberellin, GA 4/7, application at 50 mg/ℓ promoted flowering of non-vernalized heat tolerant varieties; it also served to supplement vernalization of heat sensitive varieties (Table 5).

Table 5. Effect of GA 4/7 application on flowering of non-vernalized Chinese cabbage, 1977, AVRDC.

Acc. no.	Varietal name	Time of flowering with GA 4/7	
		(DAE)	
-	Chung Hua 1	54	
644	Yuan Pau 2	55	No flowering
31	Chang Puh Early	55	without GA 4/7
189	189 C1	55	
14	Bing Luh	-	
6	New King	-	

[1]All varieties are heat tolerant except Bing Luh and New King which are moderately heat tolerant and heat sensitive, respectively. DAE = Days After Emergence.

Testing AVRDC Seed Around World

We distributed 1,066 seed samples of our accessions and new breeding lines in 1977 to cooperating researchers around the world.

In a yield trial conducted at Sarawak, Malaysia, improved open-pollinated cultivars (189 C_1 and 129 C_1) from AVRDC gave yields comparable to those from heat tolerant F_1 hybrids developed by Japanese seed companies.

Out of 126 entries tested for their combining ability in the Korean Outreach Program (KOP), 10 formed marketable heads 60 days after they were sowed, on July 20. The top yield at the sub-center in Suweon, Korea, was 42.3 t/ha. The Korean TuMV virus screening planting was severely infested with clubroot pathogen (*Plasmodiphora brassicae*) at an early stage. Reaction to TuMV and clubroot was noted and 8 of the 120 entries were rated resistant to both diseases.

A heavy rain in Suweon five days after a test field was inoculated with soft rot pathogen flooded the crop and severely damaged most of the 142 entries. However, 4 accessions exhibited resistance to soft rot.

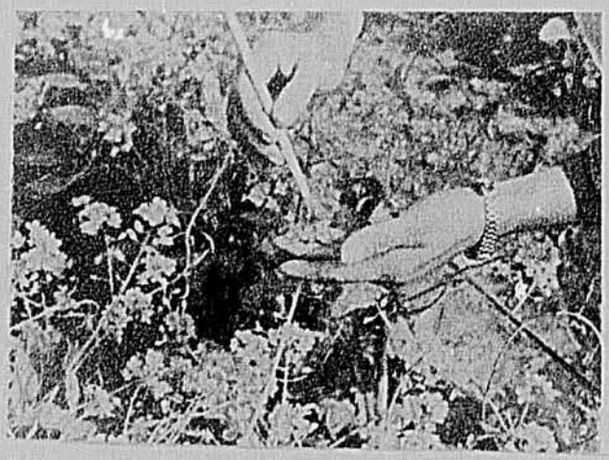
The Korean Outreach scientists found that tunnels of No. 200 mesh (13.5 lines/mm) blue plastic screen, placed over rows of Chinese cabbage, greatly reduced virus symptoms and dramatically increased yields (Table 6).

Table 6. Effect of No. 200 screen tunnel on summer grown Chinese cabbage, 1977 RES, Suweon, Korea.

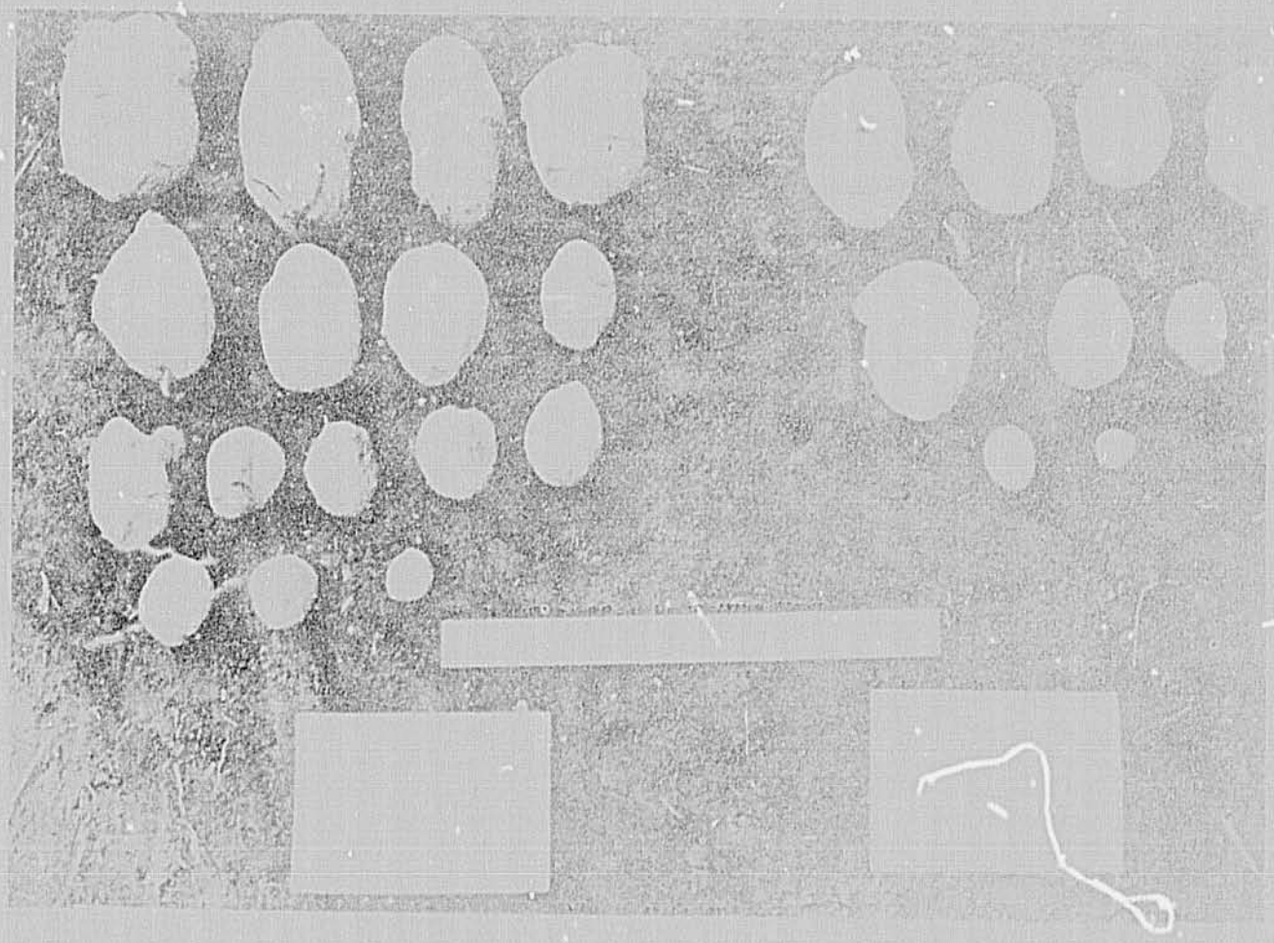
Row covering	Plants with virus symptoms	Yield
	(%)	(t/ha)
Screen tunnel	10.0	47.7
None	58.7	12.8

[a]Data from treatments with and without straw mulch were combined.

Chinese cabbage flowers being hand pollinated to produce crosses.



Most Chinese cabbage plants will not flower like they do in temperate zones. They have to be given an artificial "cold weather" treatment first in a refrigeration chamber.



Objectives

* Increase tuber production under tropical lowland conditions.

* Identify varietal resistance to major diseases in tropics.

* Improve cultural management for warm humid season production.

White Potato

Yields continue to increase in lowland tropics as ravages of disease and insects are gradually overcome.

Varietal Improvement

No international addition to the germplasm collection was made in 1977. One local variety was collected within Taiwan.

Outstanding Cycle 2 clones selected during the 1976 summer season were crossed in diallel fashion to develop a Cycle 3 population for additional recurrent selection cycles. A number of heat tolerant selections were also crossed with two bacterial wilt resistant accessions identified by the AVRDC plant pathologists.

We continued to screen segregating populations for heat tolerance. Out of 3,211 seedlings, 52 selections with excellent yields relative to Kennebec (check variety) were isolated (Fig. 1). Further selection will be made on the basis of other horticultural characteristics.

We also evaluated heat tolerant clones for their late spring season performance in southern Taiwan. During this season, early growth occurs under moderately cool temperatures but tuber enlargement stage coincides with increasingly warm temperatures and longer photoperiod. Three clones were selected with excellent yields compared to check varieties Kennebec and acc. 525. Kennebec exhibited some degree of heat tolerance.

One selection (33-6-105) significantly outyielded Kennebec in a replicated trial of heat tolerance. This clone also had higher tuberization efficiency relative to Kennebec.

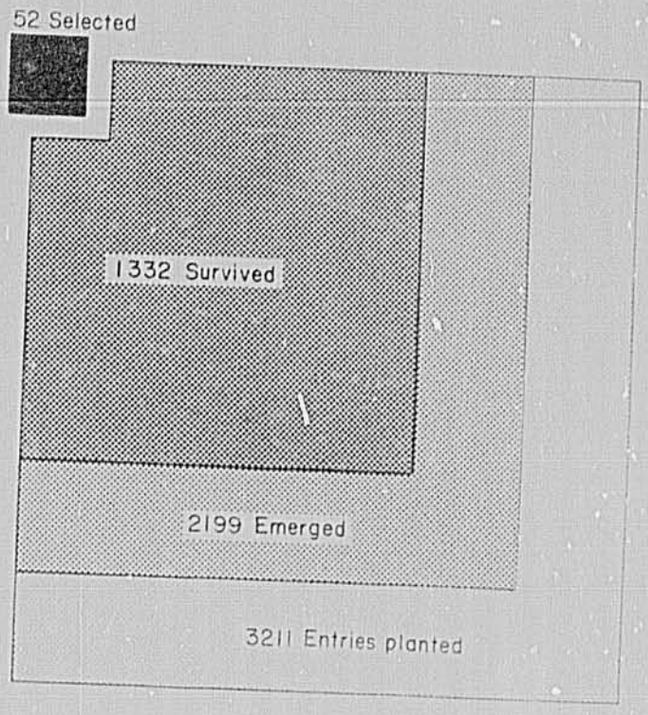


Fig. 1. Summary of potato segregating populations screened for potential heat tolerance, 1977, AVRDC. Planted Sept. 7; harvested Dec. 14.

Three previously untested selections, 1282-12, 1284-9, and 1289-6, outyielded the heat tolerant checks (1282-1 and 1282-17) in another trial to evaluate heat tolerance. Of these 3 clones, one showed comparable tuberization efficiency, emergence rate, and survival rate relative to the check entries.

Bacterial Wilt Resistance Screening

In a preliminary field screening for bacterial wilt resistance, 10 out of 72 clones tested were rated resistant. A total of 103 clones were screened for bacterial wilt resistance under greenhouse conditions using Kennebec and Norin 1 as check varieties. Fig. 2 shows the summary of these screenings. Three clones, accessions 15 (WIS-BR-69-92), 422 (WIS-BR-63-20), and 499 (WIS-BR-69-107) remained healthy. Kennebec was rated as moderately susceptible. Incubation of inoculated plants of acc.499 at 32°C resulted in breakdown of resistance and plants wilted 3 days after inoculation.

Tissue Culture

Production of virus-free clones through meristem culture was initiated. The cultural method is outlined in Fig. 3. Of 22 heat tolerant selections, nine had been successfully regenerated into plantlets. Only Norin 1, a heat sensitive variety, had been through the process of branching, virus-indexing of plantlets, *in vitro* tuberization, and nethouse multiplication.

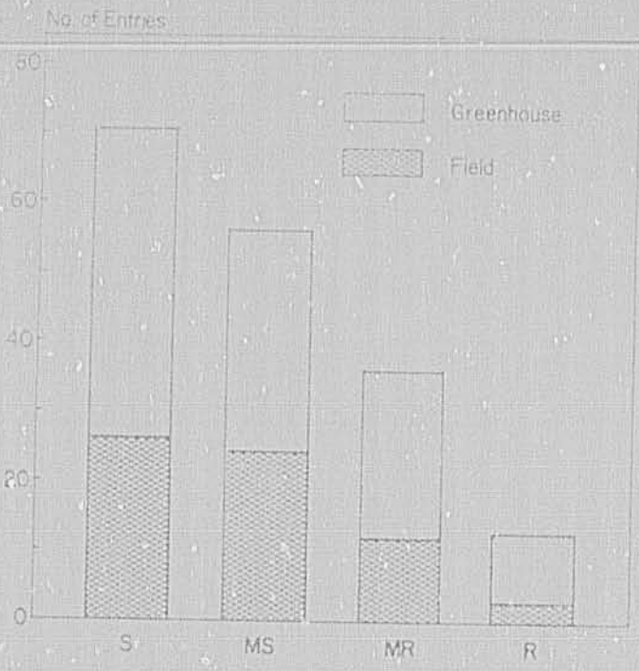
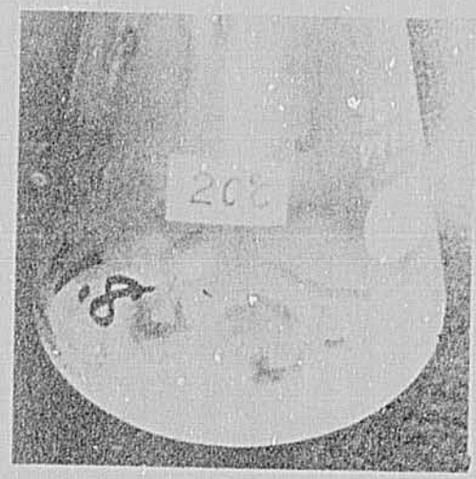
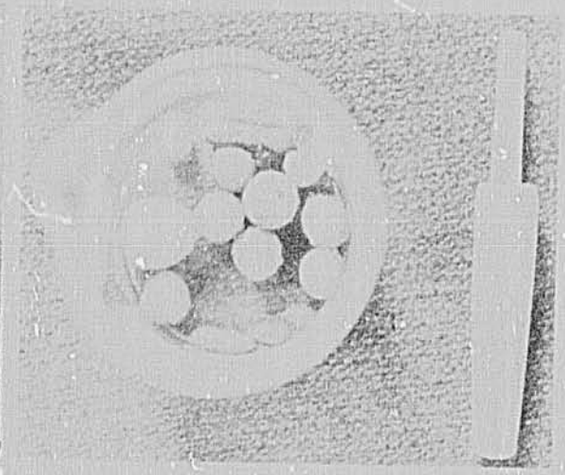


Fig. 2. Results of field and greenhouse screening of potato clones for resistance to bacterial wilt, [illegible], 1977, AVRDC.





Upper left, tuberlets forming in MS media with added plant hormones. Above, tuberlets from meristem culture. Left, plants grown from above tuberlets.

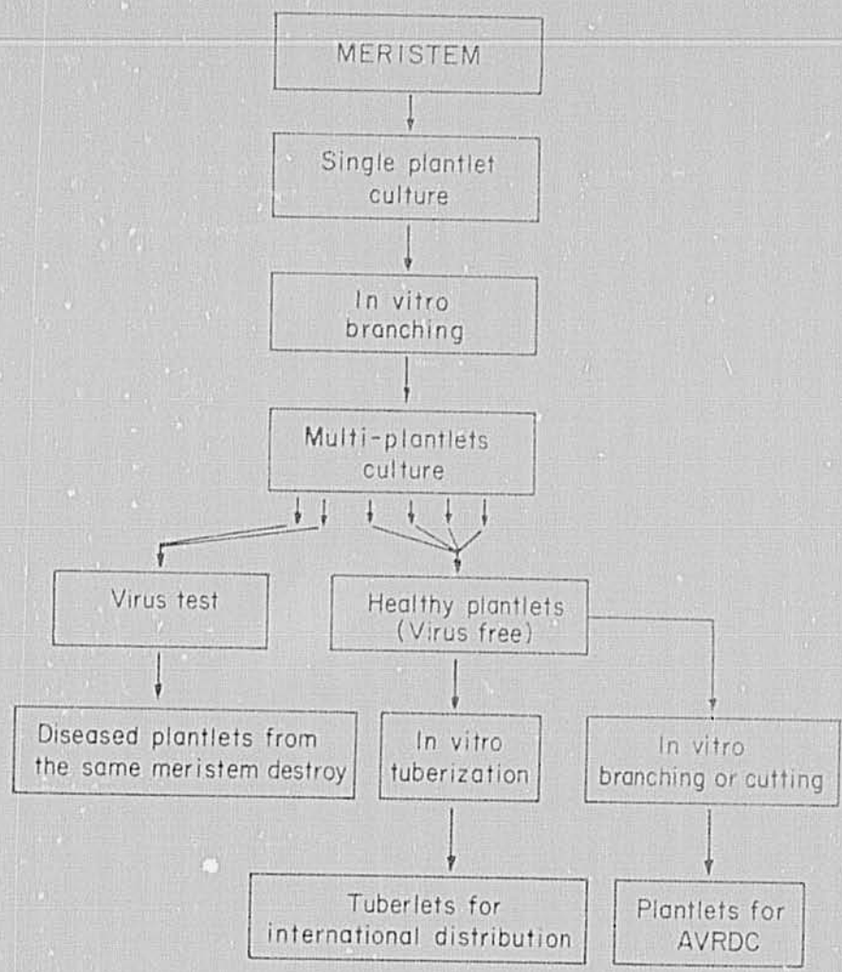


Fig. 3. Meristem culture system for virus-free white potato, 1977, AVRDC.

In vitro tuber formation was tested as a possible tool for physiological studies since the technique requires relatively small space with accurately controlled environmental conditions. Preliminary results shown in Fig. 4 indicate that *in vitro* tuber formation of Norin 1 was optimal at 16-20°C, a range expected for heat sensitive, temperate climate bred varieties.

Fertility Trials

In a fertilizer trial conducted during the 1976-77 winter season, significant yield increase (42%) was obtained over uncomposted and unfertilized plots by adding 60 kg N/ha. The highest yield without compost was obtained in plots with 120 kg/ha N and 100 kg/ha K. In a related experiment where 20 t/ha of compost was added, the highest yield was in the plots with no K and 120 kg N/ha.

International Cooperation

In an observational lowland tropics trial conducted at the Twin Rivers Research Center in the Philippines, 5 AVRDC heat tolerant selections outyielded the local variety by at least 5 times (Table 1). Selection 1282-19 gave the highest estimated yield of 21 t/ha in 80 days cropping duration. At slightly higher elevation (300 m above sea level), 2 of the AVRDC breeding lines (1282-17 and 75-0-827-102) yielded at least double the local check.

Two promising AVRDC breeding lines gave yields much higher than other entries, including the newly introduced varieties, Resy and Climax, in a preliminary yield trial conducted by the Taichung District Agricultural Improvement Station for spring cropping in central Taiwan. Selection 1284-20 is reportedly preferred because of its good eating quality, uniform tuber size and shape, and abundant growth.

In an intercropping experiment with sugarcane, the Taiwan Sugar Research Institute (Hsin Ying Branch Station) reported 3 AVRDC breeding lines gave excellent marketable yields of better than 30 t/ha in a 96-day cropping duration.

In two other lowland tropics trials, in the Philippines and Malaysia, reports of bacterial wilt and soft rot infecting the clones were prominent, indicating the importance of incroporating resistance to bacterial wilt into heat tolerant cultivars.

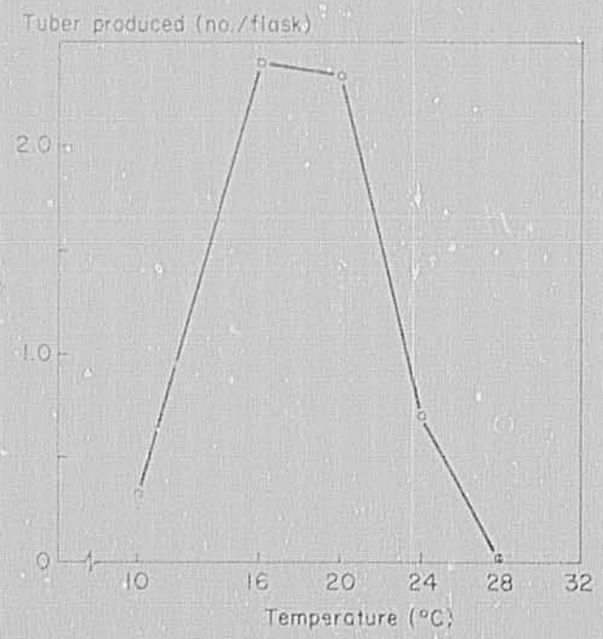


Fig. 4. Temperature effect on White Potato, Norin-1, tuberized *in vitro*, 1977, AVRDC. Average of 4 flasks.

Table 1. Yield and other horticultural characters of AVRDC white potato breeding lines tested under lowland tropics conditions, 1977, TRRC[a], Philippines.

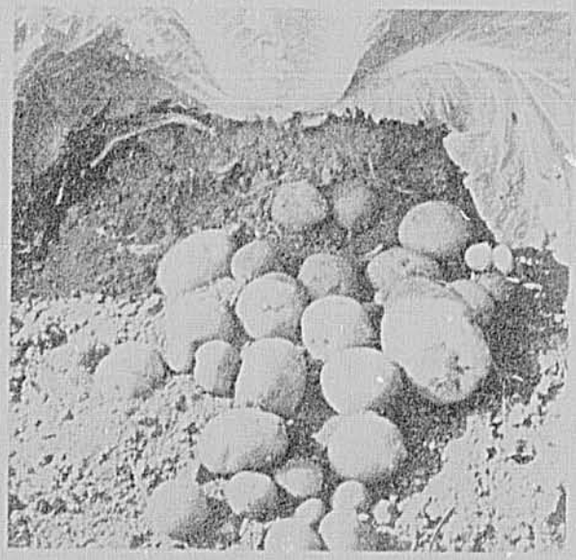
Selection/ cultivar	Emergence rate	Stand at harvest	Mean yield		Estimated marketable yield[b]	Mean tuber number		Bacterial wilt infestation rate
			total	marketable		total	marketable	
	---	---	----- g/hill	----	----- t/ha	-----	no/hill ----	------ % ------
1282-19	80	75	830	645	21.3	18	7	6
1282-17	70	55	580	452	10.9	11	5	21
33-16-140	65	65	590	373	10.7	22	6	0
75-0-827-102	70	45	422	333	6.6	9	5	36
Local check	80	30	167	160	2.1	10	3	45

[a]Planted Jul 21 and harvested Oct 8, for an 80-day duration. [b]Uncorrected for plant stand. TRRC is located at 5 m, minimum temperature > 23°C.

In 1976-77, at the Korean Sub-Center near Suweon, Korea, 681 accessions were imported from advanced breeding programs throughout the world. Napoor gave best control of weeds in spring trials.

The practice of delaying harvest was evaluated at Unbong area. Tubers which matured in July were left in the soil until late October. During this period, Chinese cabbage, sweet potato, and buckwheat were successfully grown on top of the potatoes and harvested before the potatoes were dug. At harvest in late October the tubers were in excellent condition with little evidence of insect damage or rot. Although 70 percent of tubers had sprouted, sprouting seemed to have little effect on quality. In Table 2, tubers from delayed harvest are compared with those lifted in July and stored at room temperature until October 26.

Potatoes harvested with Chinese cabbage after 3 months of in-ground storage at Unbong, Korea.



Chinese cabbage growing above delayed harvest potato Unbong, Korea.

Sweet Potato

Objectives

* Higher productivity of roots rich in beta carotene content and protein with resistance to sweet potato weevil and witches' broom disease.

* Development of management practices to optimize farmers' returns.

* Identification of factors and constraints affecting the production, marketing and consumption of sweet potato roots and tips.

Gains made in yield, disease and insect resistance and management knowledge.

We now have a total of 389 cultivars in our collection. We received 15 cultivars from Louisiana State University and 9 cultivars from the Indonesia Central Research Institute for Agriculture.

Accessions which were identified in 1976 as resistant to witches' broom disease were used in crosses in 1977 to incorporate that resistance with good horticultural characteristics. Screening to identify sources of resistance to sweet potato weevil contined in 1977 in more locations. In addition, combinations were made for high yield potential, high amount of beta-carotene and protein, and good eating quality.

Cool Season Trials

In the early cool season evaluation, planted in September at AVRDC, one of our breeding lines outyielded the check cultivar when we harvested the sweet potatoes in 120 days (Table 1). The total yield of selection 243-2 was increased by 14%, to 49 t/ha, when harvesting was delayed by 10 days (130-day crop duration). Its short growing period and high productivity (377 kg/ha/day) makes selection 243-2 a desirable breeding material In general, the high yielding selections had lower vine/root ratio -- the ratio of the fresh weight of the vines to fresh weight of the roots.

Selections Give Good Winter Yield

In a November evaluation, we harvested plots in 150 to 167 days after planting. Yields varied from 0 to 29 t/ha. Selection 380-302, a cross between OK8-25 and Rose Centennial, yielded 29 t/ha compared to 18 t/ha for the check, Tainung 57. These materials will be evaluated in the

Table 1. Best performing sweet potato breeding lines in cool season trial, 1977, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar) name	Marketable yield	Total yield	Chip/root ratio[b]	Vine/root ratio
		------- t/ha -----		-- % --	- fresh wt -
243-2	B 6708/Tainung 56	34	43	21	0.52
0122-2	B 6708 (op)	21	28	22	0.62
01-2	BNAS-White (op)	19	25	22	0.58
35-2	HDK 6/B 6708	18	24	24	0.67
(57) (check)	Tainung 57	15	22	24	0.83
	LSD .05	7			
	.01	10			
	CV	27			

[a]Trial with 10 entries conducted at AVRDC by R.S. Liu, AVRDC Production Intern from Hsinchu District Agricultural Improvement Station (Sept 1976 to Jan 1977); means of 3 replications planted Sept 14, 1976 and harvested Jan 13, 1977 (120 days). [b]Dry weight of chips expressed as percent of fresh weight of roots.

International Rice Research Institute's intensive cropping experiments in rotation with rice at selected sites in Asia.

Yield in Spite of Typhoon

Our summer trials clearly demonstrated that some of our breeding lines could give respectable yields in spite of typhoons and heavy rainfall.

Nine trials with tillage (land preparation before planting) and eight without tillage were completed during summer. Trials that were

When all other summer vegetable crops were destroyed by Typhoon Thelma in July, 1977, sweet potato plots came through with some satisfactory yields of up to 18 t/ha.

tilled received 30 kg N/ha, 60 kg P/ha, and 90 kg K/ha. The no-tillage trials received no basal fertilizer. Both types of trials were side dressed with 30 kg N/ha and 45 kg K/ha. Due to heavy rains and typhoons, yields for advanced trials with tillage were low, ranging from 0 to 18 t/ha (Table 2). The vine/root ratio varied from about 1 to as high as 48. We observed that those with high yields had considerably lower vine/root ratio than the low yielders. Centennial, however, had an extremely low vine/root ratio along with a low yield. Selection 35-1, as in the 1976 summer trials, gave high yield, whereas 35-2 had low yield.

Table 2. Yield and vine/root ratio of the best yielding sweet potato (with tillage) lines in hot wet season trial, 1977, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree or (cultivar) name	Marketable yield	Vine/root ratio
		-- t/ha --	- fresh wt -
209-3	B 7078/OK 9-3	18	2.0
35-1	HDK 6/B 6708	16	1.8
209-2	B 7078/OK 9-3	15	3.6
015-6	HDK 6 (op)	12	4.0
35-2	HDK 6/B 6708	6	5.5
Check cultivars (57)	Tainung 57	4	5.7
(71)	Tainung 63	6	4.0

[a]40 breeding lines, included in 4 separate advanced trials; planted June 15, and harvested Oct 24 (141 days); vegetative stage coincided with heavy rainfall in June, July, and August, means of 3 replications.

In the no-tillage advanced trials, selection 209-2 had the highest yield of 13 t/ha. Tainung New 10 had vine/root ratio of about 5; selection 209-2 had a 1.2 ratio and 0122-2, a 2.1 ratio. The check cultivar, Tainung 63, gave 2 t/ha.

Screening for Weevil Resistance

We continued our host-plant resistance studies to identify the source(s) of resistance to sweet potato weevil (*Cylas formicarius*). We gave a third screening to selected sweet potato accessions that had been found promising during earlier screenings at the Economic Garden in the Philippines and Penghu Island in the Taiwan Straits.

Although there was a wide variation in the performance of most entries, accession 104 proved to be moderately resistant at both locations.

At AVRDC we screened 200 breeding lines for resistance to the weevil. Eighty-four entries from this preliminary screening were tested at Penghu Island. Three entries, 322-2, 329-2, and 329-3, proved to be resistant at both locations.

Pruning of vines at one month resulted in 33% greater yield of sweet potato roots and 10% more marketable roots than the check plot.

Crop Management

To evaluate the importance of management factors to the performance of sweet potato in AVRDC trials, cultural management studies were initiated in 1976. Last year we found that weed control was a limiting factor. This year results of a cool dry season trial indicated the rototilled land, compared with rice-stubble culture, produced highly significant increases in root yield and in average root yield, and a highly significant decrease in vine/root ratio (Fig. 1). Fertilizer

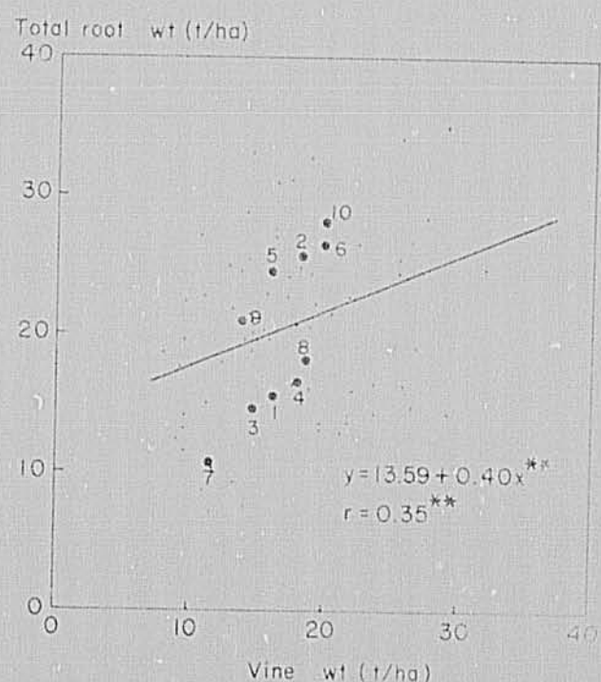


Fig. 1. Effect of land preparation, weed control and fertilizer on sweet potato line 122-2 planted Nov. 5, 1976, harvested April 13, 1977. AVRDC. Methods depicted are (1) rice stubble (2) rototilled, (3) rice stubble without weed control, (4) rice stubble with weed control, (5) rice stubble with no subsequent weed control, (6) rototilled plus weed control, (7) rice stubble without fertilizer, (8) rice stubble plus fertilizer, (9) rototilled without fertilizer, and (10) rototilled plus fertilizer.

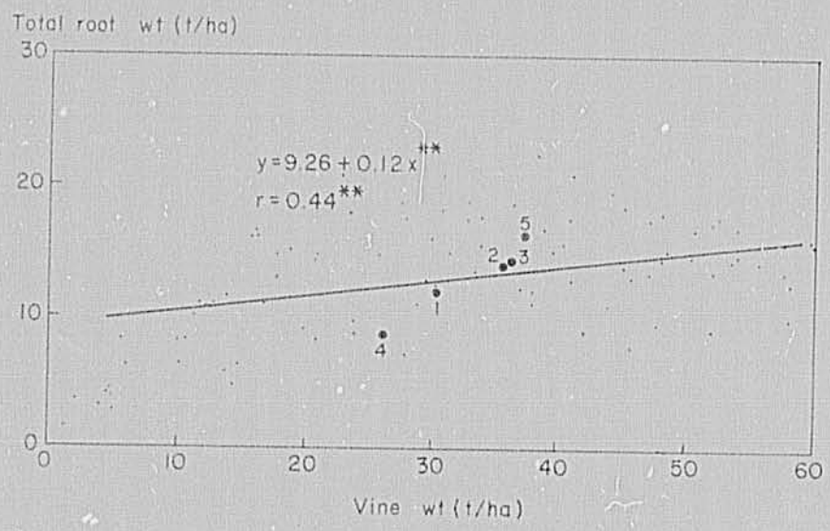


Fig. 2. Effect of land preparation and weed control on sweet potato line 35-2 planted July 11, and harvested Dec. 7, 1977, AVRDC. Methods depicted are (1) without banking, (2) with banking, (3) hand weeding, (4) chemical weeding, and (5) chemical plus hand weeding.

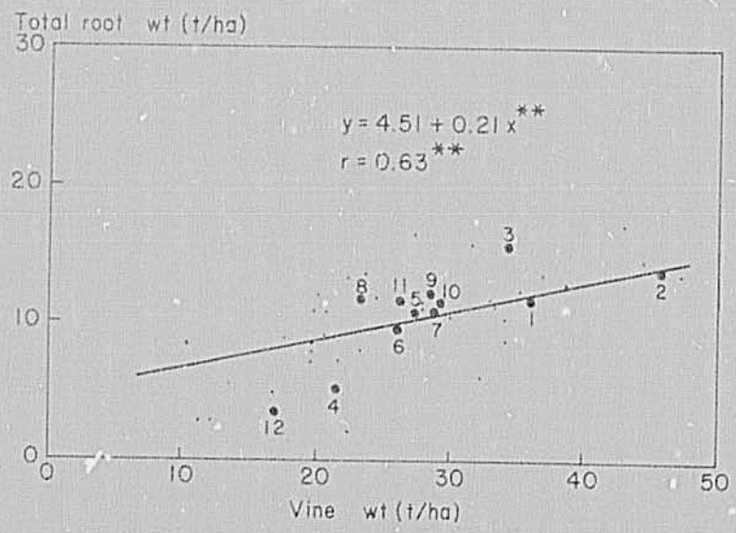


Fig. 3. Effect of top growth retardation on 35-2 planted May 13 and harvested Nov. 15. (Typhoon damage July 25.) Points: (1) check, (2) max. top growth, (3) pruned 1 mo., (4) pruned 2 mos., (5) twisted 2 mos., (6) trained at 2 mos., (7) SADH 1000 ppm at 1 mo., (8) SADH 5000 ppm at 1 mo., (9) Ethephone 500 ppm and (10) 2000 ppm at 2 mos., (11) MH-30 at 1000 ppm and (12) 10,000 ppm at 2 mos.

significantly increased total root yield, vine weight, no. of roots, average root weight. Weed control significantly increased total root yield, vine weight and weed weight. Vine turning had no effect. Another trial in the cool dry season indicated that on rototilled land there is no difference between bed and no bed culture. Banking compared with no-banking significantly increased total and marketable root yield (Fig. 2). There was no difference between hand weed control and chemical plus hand weeding. Both were superior to chemical weeding (Lasso and Paraquat) alone.

The low management level study included this no-tillage (no bed formation and no banking) plot. The row on the left was hand weeded and that on the right was with Lasso and paraguat treated.

During the wet season, sweet potatoes exhibit excessive vine growth and fail to produce large, fleshy roots. In the management level studies we noted that high yield was often associated with low vine weight to root weight ratios. To determine the effect of top growth retardation on the performance of sweet potato, crop management designed a RCB experiment with 12 treatments, including a check, use of foliar fertilizer to encourage maximum vine growth, pruning, twisting vines, training vines, SADH, ethephong and malichydrazide. Pruning at one month produced the highest root yields (33% greater than the check) and the highest number of marketable roots (10% greater than the check). Both increases were highly significant. The vine weight to root weight ratio for this treatment was 31% lower than the ratio for the check (Fig. 3).

Study Cooperating Farmers' Records

Economists and crop management staff continued to evaluate sweet potato under local conditions through two types of cooperators: (1) Eighteen daily record-keeping households that are taking part in a two-year study of farm decision-making in Matou (irrigated) and Shan-Shang (upland) districts; and (2) two contract farmers, who each planted five target commodities on the AVRDC Experimental Farm.

Of the 2 contract farmers, Mr. Hong's sweet potato crop was more successful than Mr. Tang's in terms of yield and return per day (Table 3). He put in much more capital, notably fertilizer, and less labor than Mr. Tang in both absolute and relative terms.

Sweet potato was grown on the 18 daily record-keeping farms in 3 different ways (1) rice stubble method, planted without cultivation after the rice harvest, (2) tillage method, used on irrigated land of loose structure, and (3) intercrop with corn and edible sugar cane. Both AVRDC contract farmers used the tillage method (2).

Table 3. Comparative production efficiency of sweet potato farming practices of cooperating farmers and AVRDC contract farmers, 1976/1977. Units: US$/ha unless otherwise indicated.

Item	Matou cultural method[a]			Shan-Shang	Mr. Tang	Mr. Hong
	i (N=5)	ii (N=9)	iii (N=3)	ii (N=3)	ii (contract farmers)	ii (contract farmers)
Yield (kg/ha)	16,880	29,494	20,000	19,183	28,045	29,019
Price/ton	35	35	38	39	35	40
Days to harvest (da)	192	176	211	191	194	163
Fertilizer cost	111	139	0	29	67	133
Pesticide cost	6	0.7	0	4	4	0
Total material cost	301	385	94	210	295	372
Pre-harvest labor (hrs.)	437	578	507	405	430	396
Pre-harvest labor cost	212	290	187	153	185	168
Total labor (hrs.)	637	876	733	766	730	805
Total labor cost	316	425	262	285	333	316
Net return/ha	-316	- 67	13	128	166	291
Net return/ha/day	- 1.65	- 0.38	0.06	0.67	0.86	1.79
Net return/hr	- 0.05	- 0.08	0.02	0.17	0.23	0.36
Farm income/ha	189	490	519	458	643	549
Farm income/ha/day	0.98	2.79	2.46	2.40	3.31	3.37
Farm income/hr	0.30	0.56	0.71	0.60	0.88	0.68

[a] i = rice stubble method, ii = tillage method, iii = intercrop with corn and edible cane.
Source: Survey data, 1976-1977.

In Matou and Shan-Shang, there has been a steady decline in area planted to sweet potato for ten years. The annual rate of decline in Matou has been 5.5% from a much higher base, while the rate of decline in Shan-Shang has been 8.5%. These patterns agree with the general decline in sweet potato plantings throughout Taiwan since 1971.

What the Records Revealed

On the basis of the information above, production budgets, and simple regression analysis, we were able to accept the following hypotheses:

1. The higher the yield the higher the net return. For every metric ton of increase in yield, the sample farmers realized a US$ 41 increase in net returns.

2. Up to US$ 384/ha investment in material, inputs contributed to increases in yields; however, over-investment by many farmers caused negative or low correlations betwen capital inputs and yields.

3. The higher the investment in human labor, the higher the yield. For every extra 8-hour day of labor input, yields increase approximately 2 kg/ha.

4. The most labor-intensive operations are planting and harvesting, regardless of cultivation method. These operations represent 15-25% and 31-51% of total labor inputs, respectively.

5. Regardless of cultivation method, sweet potato is less labor and capital intensive than alternative vegetable crops which may be grown in the fall.

6. Highest net and farm return are associated not with high yield but with low cost. With the falling demand and hence declining price of sweet potato in Taiwan, low input and/or low cost technology is essential.

7. Sweet potato yield and profitability were distinctly different in the three locations, Matou, Shanshang, and AVRDC.

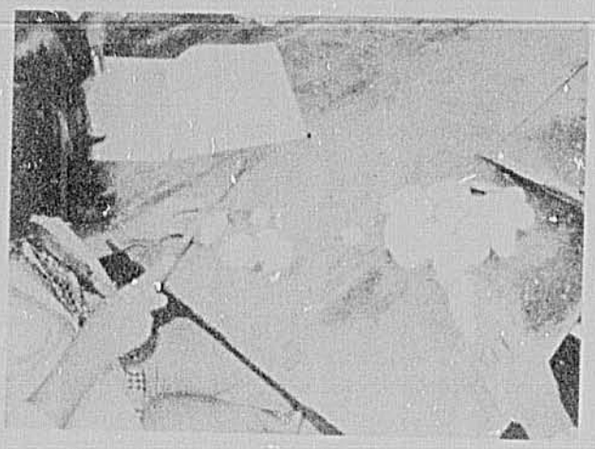
INTERNATIONAL COOPERATION

Nueva Ecija, Philippines

Cooperators at Central Luzon State University compared the performance of 17 AVRDC breeding lines provided through the Philippines Outreach Program. Yields varied from about 13 to 41 t/ha. Seven lines yielded at least 20 t/ha. Local cultivars did not produce roots in 110-day crop duration.

Laguna, Philippines

Scientists at the Philippines Outreach Program's Economic Garden research station conducted an advanced yield trial of 20 AVRDC sweet



Staff members of AVRDC's Philippine Outreach Program slicing sweet potato roots from variety tests to determine resistance to weevil.

Table 4. The best performing accessions and breeding lines in advanced trials; 1977, Economic Garden, Philippines.

Entry	Marketable yield		Flesh color
	t/ha		
	125-day	159-day	
PI 318548	22	33	Yellow
PI 344129	24	26	White
BNAS(check)	22	25	Yellow
Daja 380	20	29	Yellow
PI 318852	18	20	White
PI 143907	16	22	Yellow
AIS 35-2	15	23	Orange
B 6708/OK 9-1	15	19	Orange
LSD .05	3.6	7.1	
.01	5.1	8.5	
CV (%)	22.5	24.5	

Data supplied by Bureau of Plant Industry, AVRDC Philippine Outreach Program; Planted Nov 19 (1976), harvested March 25 (125 days) and April 27 (159 days); 20 entries included in the trial; means of 3 replications.

potato lines and accessions. The experimental materials were hand watered at planting; otherwise the crops were rainfed.

Marketable yields varied from 2 to 24 t/ha in 125 days crop duration and from 7 to 33 t/ha when harvested at 159 days. Only 3 accessions had comparable yields to BNAS, the local check, when harvested in 125 days (Table 4). However, in the 159-day crop duration, PI 318548 significantly outyielded the check, and yields of 3 accessions and selection 35-2 (orange flesh) compared favorably with BNAS.

Misamis Oriental, Philippines

The Philippine Packing Corporation planted 86 AVRDC materials and 14 local cultivars. Breeders selected 12 lines for further trials on the basis of good yield and earliness.

Bangladesh

International Voluntary Services reported AVRDC selections 35-1 and 140 to be superior to varieties available locally. Farmers of Sylhet District found these AVRDC lines produced much larger harvest of more nutritious and attractive roots than the traditional white-fleshed varieties.

Indonesia

The Central Research Institute for Agriculture conducted a yield trial of some AVRDC breeding lines. Local check cultivar Daja 380 out-yielded most of the entries. Selection 128 was an exception. Yields ranged from 9 to 28 t/ha in a 156-day crop duration. These materials are currently being evaluated in other sweet potato growing areas in Indonesia.

Thailand

Kasetsart University conducted eight sweet potato experiments which included AVRDC materials. Twelve members of a taste panel from the University's Home Economics Department evaluated eating quality of 18 AVRDC sweet potato breeding lines and Okud, a local cultivar. AVRDC lines had comparable eating quality to Okud. Our lines have higher β-carotene than Okud, a distinct nutritional advantage. The taste panel rated selection 35-1 first in color and flavor and fifth in texture. They rated 041-1 first in texture, second in color, and sixth in flavor.

To crosshreed mungbean varieties, the stigma carrying pollen from a male parent flower (in forceps) is rubbed against the stigma of the seed parent.

Mungbean

In 1977 we added 141 *Vigna* sp. accessions to our germplasm collection, making 4,696 accessions in total. Two lines of *Vigna radiata* var. *Sublobata*, a possible ancestor of both mungbean and blackgram, were obtained from Belgium. We found these easy to cross with both mungbean and blackgram.

Breeding for High Yield and Disease Resistance

As in 1976, mungbean yields were considerably higher during the summer season with a mean yield of 2.1 t/ha compared with 0.9 t/ha in the spring and 1.5 t/ha in the fall. Trials included 17 elite cultivars and 3 AVRDC breeding lines (Table 1). Fast and vigorous mungbean growth under hot summer conditions resulted in a high daily production rate of 30 kg/ha per day in the summer seasons, compared with only 12 and 20 kg/ha per day for the spring and the fall plantings, respectively. This suggests that mungbean should be planted during the hot season to fully

Table 1. Mean yield components, yield, maturity, and daily production rate of 20 elite mungbean cultivars, 1977, AVRDC.

Planting date	wt/1000 seeds	seeds/ pod	Pods/ plt.	Plant yield	Yield	Mean maturity	Daily production rate
	-- g --	-no.-	-no.-	g/pl.	kg/ha	-- da --	- kg/ha/da -
Mar 8	56	12	10	6.2	900	80	11
Aug 11	48	11	11	15.3	2100	72	29
Sep 15	54	12	12	10.4	1500	76	20

$$\text{Mean maturity} = \sum_{i=1}^{i=n} \frac{(\text{No. of da. from planting to harvest}) \times (\text{wt. of beans picked at harvest})}{\text{Total harvest wt.}}$$

where n = harvest number

Objectives

* Higher yielding and more uniformly maturing cultivars.

* More stable and widely adaptible cultivars with multiresistances to *Cercospora* leaf spot, powdery mildew, root diseases, and viruses.

* Identify and incorporate tolerance to beanflies, weevils, and pod borers.

* Develop management practices to maximize farmers' profit.

express its genetic potential. CES 1D-21, a newly released Philippine cultivar, performed well at AVRDC in the summer yielding 2.6 t/ha in the elite yield trial and 2.9 t/ha in the advanced yield trial. It also was resistant to lodging.

A total of 552 crosses were made from 80 parental lines to combine high yield potential and uniform maturity of various Philippine cultivars with the disease resistance (mainly to powdery mildew, *Cercospora* leaf spot, and mungbean mottle virus) of lines primarily from India. One AVRDC breeding line (1089-B-29-3B-2-B) had a yield of 3.18 t/ha in a replicated advanced yield trial in the summer season. This is the highest mungbean yield recorded to date on the AVRDC Experimental Farm. The same breeding line also performed well in the Philippines.

AVRDC pathologists continued to screen the mungbean germplasm collection for resistance to *Cercospora* leaf spot (*Cercospora canescens*), powdery mildew (*Erysiphe polygoni*), and mungbean mottle virus (MMV) under natural epiphytotic conditions supplemented by individual plant inoculations with causal pathogens. All accessions recorded as resistant in previous screenings were rescreened in the greenhouse or field to confirm their resistance.

Only 6 accessions were rated as resistant to *Cercospora* leaf spot from an initial screening of 1,200 newly acquired accessions. Our pathologists inoculated, 5 times, accessions previously rated as resistant to *Cercospora* leaf spot, in a greenhouse screening. Of the 45 entries, 6 proved to be resistant and will be used by breeders in our hybridization program. These resistant lines, ML-5, LM 612, ML-3, PLM 944, PLM 945, and PLM 888, are all of Indian origin.

Sixteen accessions out of 444 tested in a preliminary screening were rated as highly resistant to powdery mildew. A field screening confirmed that 13 out of 214 previously selected accessions have high resistance to powdery mildew. They are M 163, M 1936, PI 363152, PLM 187, MT 32/2B, PLM 224, PLM 731, PLM 822, PLM 857, PLM 863, PLM 873, PLM 944, and PLM 1060. All of them came from India except M 1936 which is from Australia and PI 363152 which is of unknown origin.

There was highly significant correlation (r = -0.34) between photoperiod sensitivity and powdery mildew resistance among 186 accessions tested. In other words, most accessions that were resistant to powdery mildew were also sensitive to photoperiod.

We found that 4 accessions (ML-3, PLM 689, PLM 944, and PLM 945; all Indian lines), were resistant to both *Cercospora* leaf spot and powdery mildew.

Both Danconil 75 W at 2.5 kg/ha and Micurb-super 25% E.C. at 0.75 t/ha effectively controlled powdery mildew.

Root Diseases

A total of 308 accessions were screened for damping-off and root-rot in both spring and fall. One accession (Stb. 29) was resistant to damping-off in the spring. None were resistant to root-rot. In the fall 9 accessions were resistant to damping-off and 4 were resistant to root-rot.

Mungbean Mottle Virus

A confirmation screening for mungbean mottle virus (MMV) was done in the greenhouse in which plants were inoculated with a virulent extract of the pathogen. Seven out of 23 accessions that had previously shown resistance still displayed high resistance. Pathologists will discontinue the screening of accessions for resistance to MMV and will concentrate on testing progeny of crosses made by breeders to incorporate resistance to MMV in improved breeding lines.

The host range of MMV was studied. Mungbean, blackgram, tepary bean, cowpea, lima bean, adzuki bean, and some varieties of common beans were susceptible to MMV. Broad bean, peas, some varieties of common beans, and soybean were not infected.

We found that the resistance to mungbean mottle virus was controlled by a single dominant gene with no detectable maternal effect.

Nematode Nursery Established

A nematode nursery was established which will be used to screen out germplasm collection for resistance to this severe, yield limiting pest.

Insect Pests - Resistance and Control

Our entomologists continued to screen the mungbean germplasm collection for resistance to beanflies (*Ophiomyia phaseoli*, *O. centrocematis*, and *Melanagromyza sojae*), pod borers (*Heliothis armigera*, *Etiella zinckenella*, and *Maruca testulalis*) bean aphids (*Aphis craccivora*), and cowpea weevil (*Callosobruchus chinensis*).

Sixty-one out of 2496 mungbean accessions screened in nonreplicated mass screening were tentatively rated as highly resistant to beanflies.

Among 558 accessions screened for resistance to a pod borers, 50 were found to be resistant. We have modified the commercially available artificial diet for this insect in order that it can be mass reared and released in the field to create heavy population pressure for more reliable resistance evaluation.

Eleven out of 75 accessions screened for resistance to cowpea weevil were preliminarily rated as resistant. The primary infestation of this pest starts in the field; thus we have initiated a mass screening program for resistance to this insect in the field.

We tested several commercial and experimental insecticides for beanfly control in two seasons. Folimat (Omethoate) sprayed at the rate of 0.5 kg a.i./ha, 3 times at 7-day intervals beginning within a week after emergence gave best control of this pest. In storage, mixing of 0.1 to 0.5 g camphor per kilo of seed protected mungbean seeds for 2 to 3 months against cowpea weevil without impairing germination.

Improved Harvest Efficiency

The labor efficiency is increased 10 times by harvesting mungbean with sickles instead of hand picking (Fig. 1). We found great varietal differences in harvest efficiency (defined as kilogram of dry mungbean harvested by one person during an hour).

Yield Physiology

Fifteen days after first bloom, all flowers of two cultivars, M 304 and Tainan-1, were detached to study source-sink relationship in mungbean. The deflowering treatment did not decrease total number of pods or seed yield. It did increase vegetative growth in both cultivars and the number of mature pods in M 304 at harvest time. Developing pods on deflowered plants seem to mobilize assimilates more efficiently and

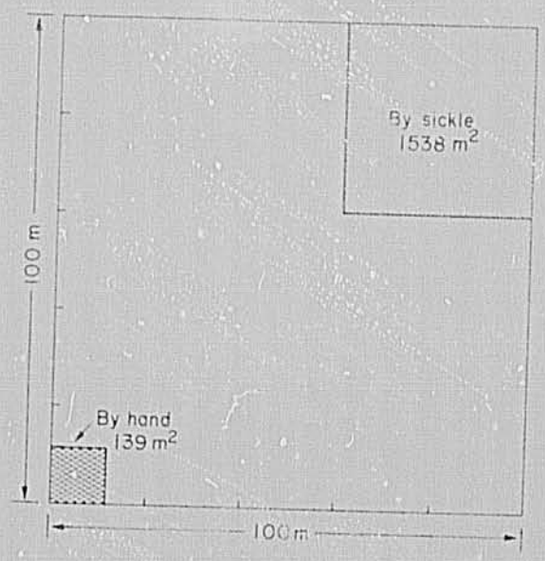
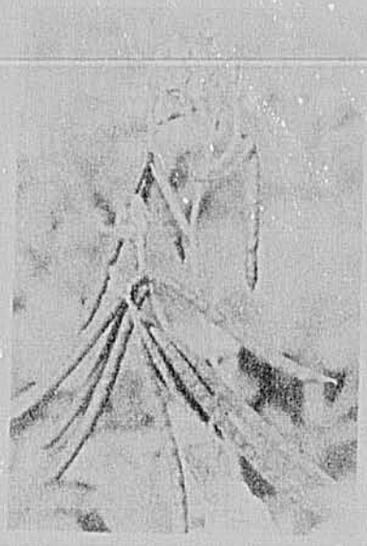


Fig. 1. The average number square meters harvested per day by sickle and by hand, based on field studies with three cultivars, Tainan 1, PHLV 18, and ML-3, planted in September, 1977 at AVRDC. Figures are for 8 hour working days and means of three harvests for the hand picking, 68, 83, and 98 days after planting. Means for the sickle are based on two harvests, 83 and 98 days after planting.



Mungbeans develop unevenly on the same plant... causing many pickings by farmers. AVRDC is developing more even-maturing plants.

thereby increase single-harvest yields. The data also suggest that longer vegetative growth appears to be beneficial to yield if translocation is efficient during the reproductive stage.

Since early vigorous vegetative growth appeared to be desirable in achieving high yield in mungbean, we screened 266 promising mungbean accessions for dry matter production, plant height, and leaf area at 33 days after emergence. Four accessions (Q, CES-140, Chunbuk Jaerae 4, and Local Cultivar 5) showed better vegetative growth.

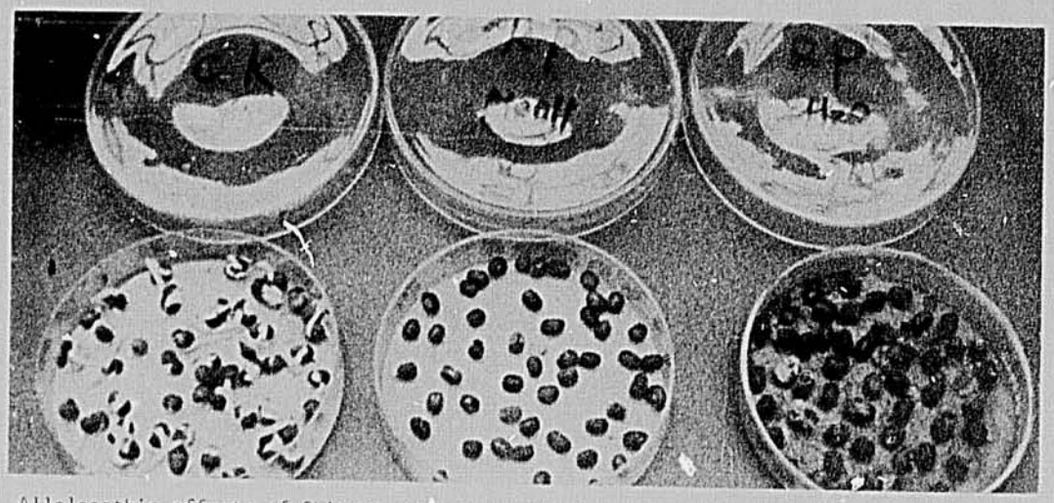
We also screened 50 of the entries in an advanced yield trial at the flowering stage for high net assimilation rate. PHLV 18, the highest yielder in both 1975 and 1976 elite yield trials, had the highest net assimilation rate at flowering.

We found that the chlorophyll content (mg/dm^2) in mungbean leaves could be determined by a Hunter Colorimeter (Model D 25A-2). This rapid, reproducible, non-destructive, and economical method may replace the expensive and cumbersome conventional way of chlorophyll measurement. The mungbean leaf chlorophyll content, at the flowering stage, is highly correlated with the net assimilation rate (Fig. 2).

Our physiologists found the mean photorespiration rate of mungbean to be higher than that of soybean, potato, Chinese cabbage, tomato, and corn (Table 2). In general, plants with a high rate of photorespiration are less efficient in dry matter production or growth. Fortunately there is genetic variation for this trait in our germplasm (Table 3).

Environmental Effects on Growth

Demand for cold tolerant mungbean lines is great since this crop is usually planted either before or after rice in Asia when prevailing temperature may be lower than the optimum for mungbean. We screened 252 promising accessions for cold tolerance at temperatures ranging from 8 to 10°C and found 12 accessions that had relatively good growth. The optimum temperature for seed germination is around 28°C.



Allelopathic effects of Chinese cabbage residues cause a reduction in germination of mungbean if planted after the cabbage, as illustrated by two petri dishes on the right which have been treated with extract of decaying Chinese cabbage leaves.

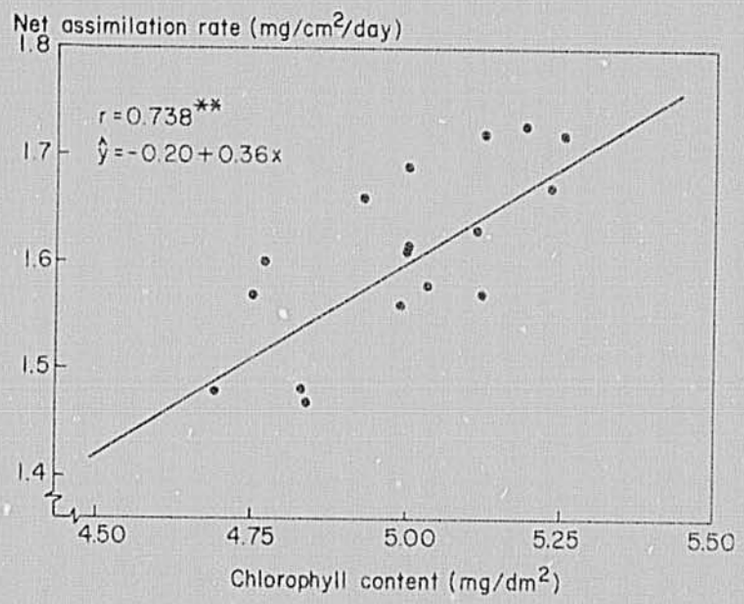


Fig. 2. Relationship of mungbean leaf chlorophyll content to net assimilation rate at flowering. Data for 17 cultivars, 1977, AVRDC.

Table 2. Photorespiration of mungbean and other crops. Release of $^{14}CO_2$ measured from leaf discs supplied glycolate -1-^{14}C in light.[a]

Crops	Cultivars	$^{14}CO_2$ released (cpm)/ hr/cm^2 [b]
Mungbean	PHLV-18	341 ± 71
Chinese cabbage	New King	244 ± 44
Soybean	Shih-Shih	210 ± 16
Potato	Norin-1	203 ± 37
Tomato	C11D-0-2-1-2-0	186 ± 11
Corn	Tainan-5	56 ± 6

[a]Followed modified Zelitch and Day (1968) method. [b]Average of three measurements using leaf discs from 6 plants of the same cultivar.

Table 3. Photorespiration of selected mungbean cultivars, as indicated by the rate of release of $^{14}CO_2$ from mungbean leaf discs supplied glycolate-1-^{14}C in light.

Acc. no.	Cultivar/pedigree	$^{14}CO_2$ release (cpm)/hr/cm^2
1016	CM-12	485 ± 116
C1168-2-8-3	CES 59/ML-5	354 ± 17
2184	PHLV 18	352 ± 152
C1209-3-8-1	ML-3/CES 55	343 ± 24
C1163-2-2-6	EG-MG-4/ML-6	259 ± 19
2013	Tainan 1	242 ± 32
1104	M 163	220 ± 76
C1163-2-2-5	EG-MG-4/ML-6	192 ± 38

[1]Three leaf disc samples from 6 plants were analyzed for each entry.

Mungbean is also susceptible to drought stress, especially at the flowering stage, mainly due to the rapid increase of stomatal resistance and decrease of the photosynthetic rate.

Monthly plantings of mungbean revealed that response to photoperiod occurs not only in the pre-flowering phase but also during flowering. Cultivars differed markedly in their sensitivity to photoperiod. At low temperature both vegetative and reproductive growth phases are longer. This was true for both photoperiod sensitive and insensitive cultivars.

Poor mungbean crops result when planted after Chinese cabbage due to the allelopathic effect of Chinese cabbage residues left in the field, AVRDC experience confirms.

Analysis of micronutrient uptake in mungbean revealed that mungbean had higher zinc content than most other crops. Also, the highest yielding cultivar, PHLV 18, had the highest zinc content in its leaves.

Integrated Pest Management Studied

Asian farmers traditionally use low levels of pesticide for mungbean production. An integrated pest management experiment was conducted to determine the effect of various combinations of insecticide and fungicide on yield, input costs, and income.

Total yields tended to increase with increasing levels of insecticide. Fungicides increased yields significantly. Rates of increase varied by cultivar. The plot of ML-5 (resistant line to *Cercospora* leaf spot) receiving no pesticide outyielded both susceptible cultivars, PHLV 18 and Local CV 1. However, with optimum protection, PHLV 18 was the highest yielder. Because of its greater appeal to local Taiwan consumers, local CV 1 brought a much higher price per kg ($0.66) than the other two varieties ($0.48 for PHLV 18 and $0.42 for ML-5) (Table 4). Therefore, at all levels of protection, the net benefit from growing this variety was greater than from the other two.

These results show that the highest yielding variety may not always give the farmer the highest profit. Local preferences, market prices, and the rate of return to additional increments of management

Table 4. Yield and net benefit from a series of integrated pest management treatments on mungbean, planted Aug 11, 1977, AVRDC

Main plot insecticide (Hostathion)		Sub-plot fungicide (Daconil)	Sub-subplot cultivar		
			PHLV 18	ML-6	Local CV 1
No. of sprayings	Yield (t/ha)	No. of sprayings	Yield (t/ha)		
None	1.8	None	1.60	1.4	1.9	1.5
		Two	1.73	1.4	2.1	1.7
		Four	2.20	2.3	2.2	2.1
Two	2.0	None	1.80	1.8	2.1	1.5
		Two	2.03	2.0	2.3	1.8
		Four	2.03	1.8	2.2	2.1
Six	2.1	None	1.83	1.8	2.0	1.7
		Two	2.10	1.8	2.4	2.1
		Four	2.40	2.5	2.3	2.4
Net Benefit	US$/ha					
None	889	None	831	699	808	987
		Two	827	635	807	1039
		Four	1010	963	708	1278
Two	903	None	866	848	824	926
		Two	930	853	843	1093
		Four	912	741	762	1234
Six	937	None	850	769	727	1055
		Two	942	739	848	1240
		Four	1020	989	725	1346

The total value of the crop minus the variable capital and labor costs for each pest management treatment.

level should be taken into account in determining economically acceptable pest control measures in a specific area.

International Cooperation

A grant from the Asia Foundation enabled AVRDC to organize with assistance from SEARCA, PCARR, UPLB, and the Department of Agriculture of the Philippines the First International Symposium on Mungbean. It was held in the Philippines, Aug 16 to 19, 1977. More than 100 participants representing 45 institutes in 16 countries discussed current status and problems in mungbean farming and research. The Proceedings are scheduled to be published early in 1978.

In cooperative yield trials in 1977, workers at Philippine Outreach Program reported that an AVRDC breeding line, 1089-B-29-5B, yielded 40% better than the newly released local check cultivar (CES 1D-21). University of Philippines at Los Baños plant breeders selected 9 AVRDC breeding lines which were resistant to *Cercospora* leaf spot in the wet season.

PHLV 18 produced an average yield of 1.3 t/ha in 7 trials in Taiwan. Four were at experimental stations and three in farmer's fields.

Forty single plants were selected from the mungbean observational nursery and breeding field in Suweon, Korea. Seeds are to be advanced at AVRDC two generations and then returned to Korea. This helps Korean breeders to accelerate their mungbean breeding improvement program.

We sent 60 mungbean cultivars to CIAT, Colombia, in 1976. They selected the seven best cultivars from the observational nursery and tested them in a replicated yield trial in 1977. The results are given in Table 5. All of their selections also have performed well under AVRDC conditions, indicating that these selections are well adapted to widely differing environments.

The Mennonite Central Committee in Bangladesh reported that lines sent by AVRDC performed poorly due to an unspecified yellowing disorder (most probably mungbean yellow mosaic virus, MYMV), except 4 Pakistani Lines (6601, PAK-22, 71-17, and 71-27) and 3 Indian Lines (OB 14, ML-3, and ML-5). Similar results were obtained in Lahore, Pakistan. MYMV is one of the most devastating mungbean diseases on the Indian subcontinent. It has not been reported elsewhere. The spread of this disease should be carefully monitored by scientists in neighboring countries.

In Sarawak, Malaysia CES 1D-21 yielded 1.6 t/ha. It outyielded other lines in the trial and was also resistant to lodging.

In Hawaii, Tainan 1 and Local CV 1 were highest yielders of 20 lines we sent them.

Table 5. Yield and other agronomic traits of the 7 best mungbean cultivars; 1977, CIAT (3°31'N latitude 76°19'W longitude) Colombia.[a]

AVRDC acc.	Cultivar name	Yield	Plant ht at maturity	1000-seed wt	Maturity
		t/ha	-- cm --	-- g --	-- da --
2010	M 317	2.3	54	70	80
1381	MG 50-10A (G)	2.3	48	67	78
1414	CES 14	2.2	70	72	78
2184	PHLV 18	2.2	47	66	80
1180	M-239	1.8	59	47	78
2773	ML-3	1.8	50	40	80
2808	Local CV	1.6	56	56	78

[a]These 7 cultivars were selected from a preliminary observation of 60 varieties sent by AVRDC. Planted on April 29 in 16 rows of 6 m in length and 50 cm apart, with 3 replications. Area harvested was 12 sq. m. Elevation of site 1000 m.

Objectives

- Breed high yielding cultivars with a range of maturities.
- Develop photoperiod insensitive cultivars with wide adaptability.
- Incorporate resistance to bacterial pustule and downy mildew in improved cultivars.
- Identify [illegible]
- Develop [illegible]

Soybean

Photoperiod Insensitive Accessions Found in US Maturity Group V

Accessions 8132 (PI 319528 from India) and 8140 (PI 346308 from India) were verified to be insensitive to photoperiod. Accessions 8025 (PI 87542 from Korea), 8082 (PI 81546 from Japan), and 8121 (PI 238928 from Japan) were less sensitive to photoperiod. All these belong to the US Maturity Group V.

Flower Induction Studied

Results from four different crosses indicated that early flowering was completely dominant to late flowering under a 10-hour photoperiod (short day). The F_2 data from the four crosses provide evidence for a single gene controlling time of flowering. Early flowering is dominant to late flowering.

In a decapitated, two-branched ack 2120 plant, the branch that was exposed to short days could induce flowering on the branch that was exposed to long days when the latter had 0 to 1 leaves. A single trifoliate leaf on the short day branch was sufficient to induce flowering on both branches. Four trifoliate leaves are capable of inducing maximum flowering. With four or more leaves on the long day branch no flower was produced.

population densities, lines with tall plant height at flowering and minimum increase in plant height after flowering will have high yield potential.

Rust Tolerant Selections

A total of 891 F_7 generation breeding lines were entered in a yield trial in which no fungicide was applied. Several of them had high yield and exhibited field tolerance to soybean rust. The 5 highest yielding selections are shown in Table 2.

Table 2. Agronomic characteristics and yield of the 5 highest yielding F_7 selections having field tolerance to soybean rust. Planted September 9, 1977, AVRDC.

Line no.	Parentage	Flowering	Maturity	Plant height Flowering	Plant height Maturity	Yield
		(days)		(cm)		(kg/ha)
[illegible]	TK 5[illegible]	40	102	[illegible]	40	3302
[illegible]	[illegible]	37	99	45	71	3000
[illegible]	[illegible]	43	102	39	73	2860
[illegible]	[illegible]	36	102	41	77	2990
[illegible]	[illegible]	38	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	40	102	[illegible]	50	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

evaluating segregating populations of crosses made to combine resistance to these pathogens.

Control of Beanflies

Infestation by beanflies within a week after plant emergence significantly reduced the plant growth and yield. No reduction in yield was noticed when the attack started three or more weeks after germination. This led us to conclude it is essential to control the beanflies during the first three weeks of plant growth to prevent yield loss. The number of plants damaged by beanflies was more than 90 percent throughout the year except in February when it was below 40 percent.

From two insecticide screening trials, Folimat (Omethoate) and Triazophos (Hostathion) spray gave satisfactory control of beanflies when applied at 0.5 kg a.i./ha, three times, at weekly intervals beginning one week after emergence.

Cooperative Tests Around the World

Researchers in Argentina, Egypt, Haiti, India, Indonesia, Iran, Malaysia, the Philippines, Saudi Arabia, Brazil, Paraguay, Uruguay, Colombia, Taiwan, and Thailand cooperated and conducted a number of germplasm screening and breeding line evaluation and selection trials. In Haiti, AVRDC breeding lines 30090-1-9 (R-10/Lbel) and 30094-2-16 (66-G-3/PI 200492) gave 3.5 and 3.4 t/ha.

In the Philippines, out of 477 F_3, F_4, and F_5 breeding lines screened for yield, 9 F_3, 20 F_4, and 1 F_5 selections yielded more than 3 t/ha. The 10 highest yielding breeding lines are given in Table 3.

Out of 477 screened, 132 were selected for advanced screening and evaluation in the dry season. Sixteen highest yielding lines will be included in a preliminary yield trial. Several of the selections have a high yielding acc. 2120 as one of the parents. Two AVRDC lines qualified for entry in national regional trial.

Eighty of our lines were entered in the first regional yield trial during the rainy season at Prachuabat, Thailand and 20 were selected. During the dry season these 20 lines were planted at Chainat and at Mae Jo Experiment Station in Chiang Mai. Breeding line 30251-1-6 (Clark 63/64-47) gave higher yield than that of three local check cultivars (SJ 1, SJ 2, and SJ 4). These 20 selections will be entered in regional trials at more locations.

In Korea, three pod borer tolerant AVRDC segregates were compared with the popular Korean variety Kwangkyo at the Korean Outreach Station near Suwon, Korea. AVRDC breeding line 30234-1-6 (Wilkins/CH 3) produced the highest yield with least pod borer damage. Five pedigree populations line 30245 (64-61/PI 197550) population yielded well and were [illegible] Korean [illegible] and resistant [illegible] the current leading Korean varieties are showed [illegible]

Nutrition Environment, & Management

Objectives

* Identify environmental and socio-economic factors related to vegetable production, marketing, and consumption.

* Improve nutritional quality of vegetable crops.

* Increase vegetable production through soil and crop management practices.

* Evaluate new technology under farmers' conditions.

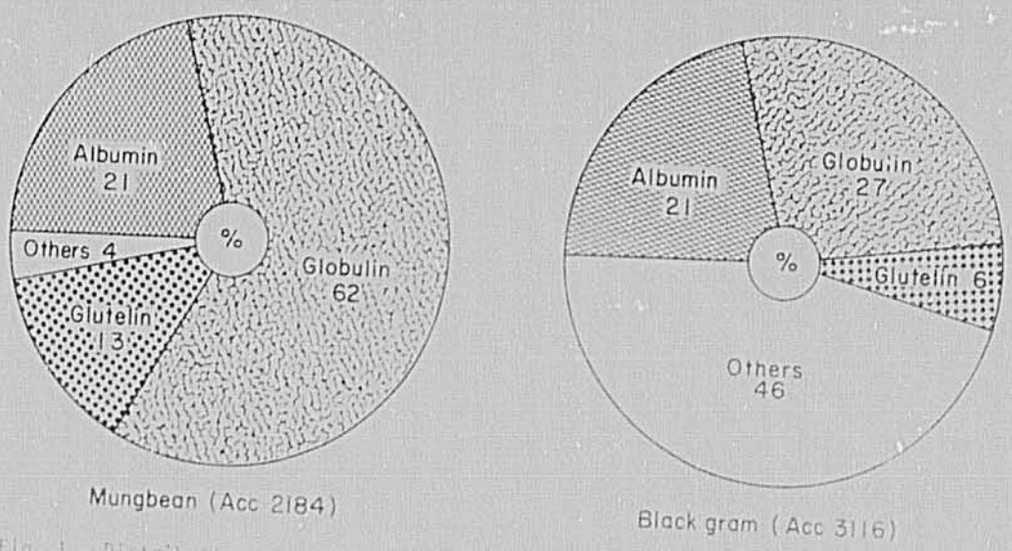


Fig. 1. Distribution of sulfur containing amino acids in protein fraction of mungbean and black gram, 1977, AVRDC. (Protein content 0 in both.)

Enriching either methionine or lysine does not improve the nutrition value of rice/mungbean mixed diet (25% protein from mungbean and 75% protein from rice). However, protein efficiency ratio can be slightly improved by enriching methionine and lysine simultaneously.

Chemical Indication of Soybean Growth Potential

The relationship between leaf nitrate reductase activity (NRA) and growth potential of soybean plant at early growth stage was reconfirmed in a field experiment. The response of induced NRA in the first and second trifoliate leaves of soybean plants, at different nitrate concentrations under hydroponic system was also studied (Fig. 2). It may be possible to use the maximum inducible NRA at a given nitrate concentration to identify high yielding soybean plants in the future.

Soil and Crop Management

Crop management scientists studied field operations of local farmers. Several popular methods were evaluated on the AVRDC farm for their potential of wider adaptability in Asia. Optimal land preparation methods for white potato were studied. Initial results indicate that placement of compost in the hole with the white potato seed piece increases percentage of plants emerging and number of tubers harvested.

For rainy season plantings of mungbean, providing protection against *Cercospora* leaf spot was more important in increasing yield than insect pest management.

Water Logging Trials

Excessive water during the rainy season inhibits emergence of mungbean and soybean, and causes wilting of tomato plants. Legume seed treatment with fungicide increased emergence percentage. Excessive water occuring immediately after planting reduced emergence (Table 1). Tomato waterlogging trials at AVRDC and in Shan-Shang on sandy loam indicated that excess water was a greater problem on the AVRDC silt loam soils. The addition of compost improved plant survival. Benzyladenine did not increase survival under wet field conditions.

An initial study on drip irrigation of tomato was conducted jointly with Chia-Nan Irrigation Association and the Agricultural Engineering Research Institute of Taiwan. Comparisons indicated that drip-irrigation produced a 40% increase in yield over furrow irrigation with a 40% savings in water. There was no significant difference between maintaining plots above 25% available water and above 80% available water.

Response of Soybean to Water Stress

Soybean yield response to five soil water regimes (0 to 1.0 bar at 0.1 bar intervals) with two levels of N (0, 300 mg/pot) was studied. We started treatments during the flower initiation stage and continued them until the pod filling stage. The seed yield and protein content as well as the number and dry weight of nodules decreased with the decrease of soil water content, regardless of the N treatment. To attain high soybean yield, water potentials lower than -0.4 bar from flower initiation to the pod filling stage, should be maintained.

Mungbean Response to Soil Fertility and pH

A preliminary experiment last year showed that N, P, and K application had little or no effect on mungbean yield under AVRDC soil conditions. The effect of compost and nitrogen on mungbean yield was further studied in this year. Neither compost nor N affected seed yield for plantings in the first and second week of September. A mungbean yield of 2.38 t/ha was achieved without the application of compost or nitrogen. In the April planting, a significant yield improvement was observed from application of compost. The highest yields in all plantings were at moderate levels of nitrogen of 30 kg/ha. It seems that high dosage of nitrogen fertilizer is not necessary, at least on the AVRDC experimental farm. The mean yield of mungbean planted Apr.6, Sep.7, and Sep.14 was 1.6, 1.7, and 2.4 t/ha, respectively.

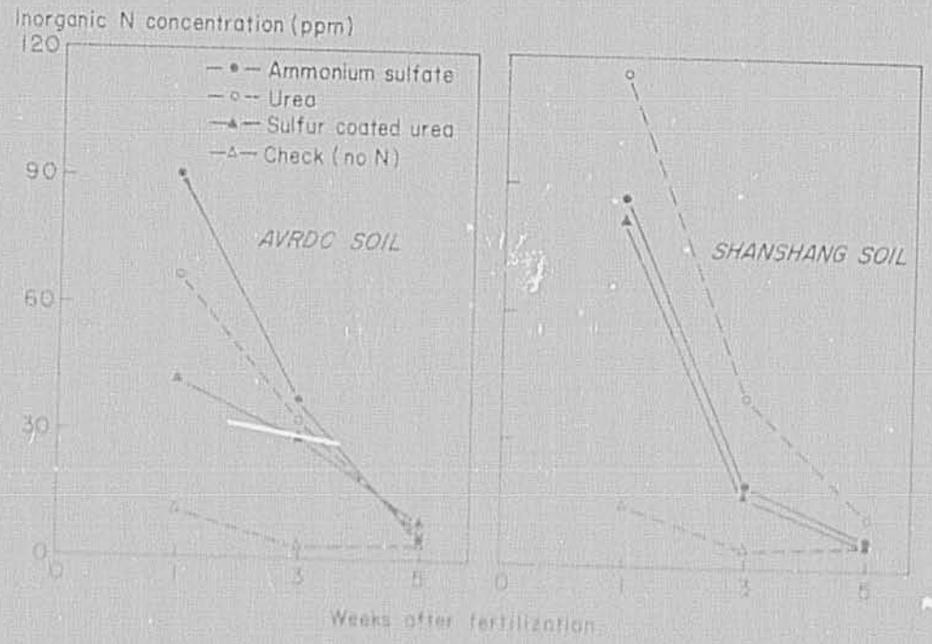
Low soil pH is often considered as having negative effect on mungbean yield. A pot experiment was conducted to clarify this point. AVRDC field soil (original pH 6.0) and Taintung red soil (original pH 4.5) were used after pH adjustments (pH 4.5-8.5 at 0.5 intervals). AVRDC soil yield was highest at pH 8.0. The highest yield for Taintung red soil was at pH 5.5-6.5.

Fertility Trials

[illegible]

Experiments with N Fertilizers on Soybean

Effects of different N fertilizers (ammonium sulfate, urea, and sulfur coated urea) on soybean growth and yield were examined. The release rates of inorganic N (NH_4-N and NO_3-N) in two soil types (AVRDC loam and Shan-Shang sandy loam) are illustrated in Fig. 3. The soil inorganic N concentration reaches the same level as the check for all these N fertilizers, including sulfur coated urea, after 5 weeks. The relative release rate of these N-fertilizers are different in these two soil types. In AVRDC soil the yield of soybean seed was directly related to the amount of inorganic N-formed. In Shan-Shang soil, on the other hand, sulfur coated urea plot gave best yield although this fertilizer was not the one providing highest inorganic N to the soil.



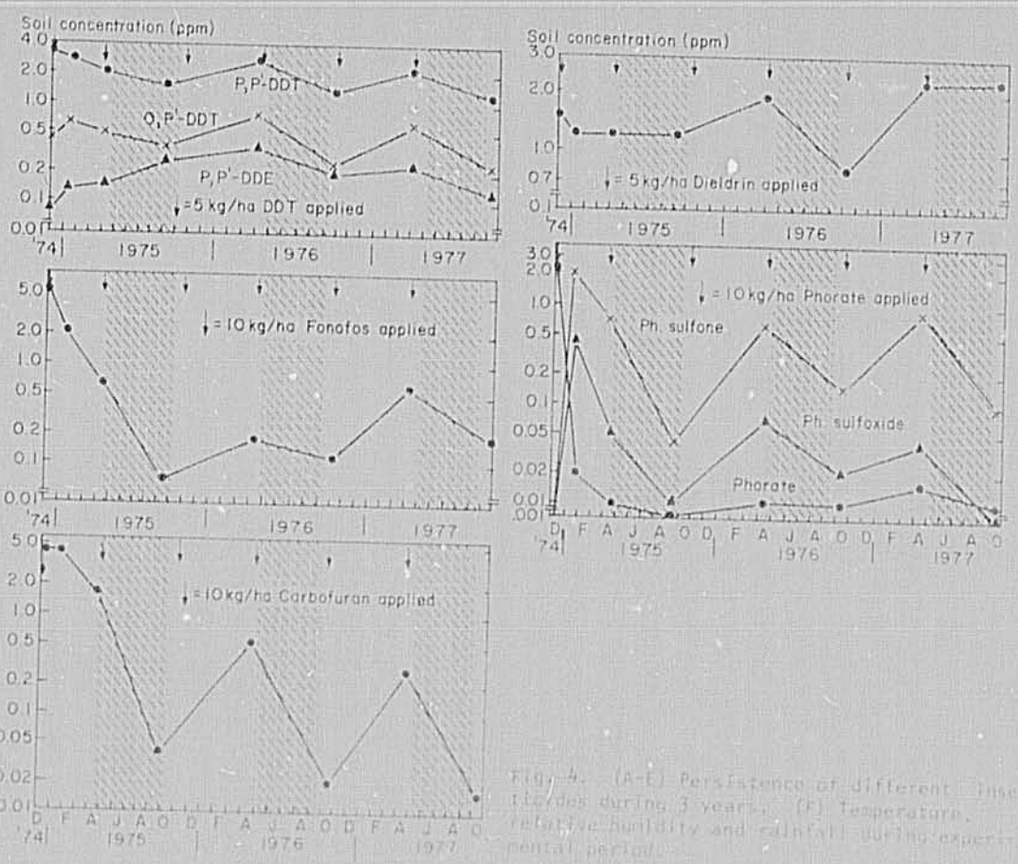


Fig. 4. (A-E) Persistence of different insecticides during 3 years. (F) Temperature, relative humidity and rainfall during experimental period.

Six crops of sweet potato and three crops of white potato were grown in this field. Although all insecticides were absorbed by sweet potato roots and white potato tubers in varying degrees, except for dieldrin in sweet potato during one season, none of the residue levels of these insecticides exceeded the tolerance levels established by United States Environmental Protection Agency for root crops (Table 2). The insecticide residues in the edible parts of each successive crop were analyzed. Higher concentrations in soil generally resulted in higher uptake of the chemicals by sweet potato and white potato. The higher residue concentration detected in white potato could be due to higher concentrations of the insecticide residues in soil during its growing period in fall and winter months.

TOO Vegetable Farmer - Sherry Reed

Our agricultural scientist has found a three year survey of vegetable producing households in Taiwan. We wanted to learn the key to the successful development of an advanced agricultural industry. This knowledge should be helpful in [illegible] answers to other comply peculiar questions about the [illegible] the crops [illegible] on the farm. The Chemical [illegible]

Crop
Environment
of Maine

Table 5: Analysis of irrigation water
Tamaris (VRBC 18/6/87 dry
season)

pH	EC micro mhos	Ca	Mg	Na	SAR
		ppm			
7.70	800	99	24	36	0.69

SAR = Na/Ca + Mg/2

Water: Irrigation water is obtained from wells tapping in depth from 20-50 m. The salt content of shallow wells increases during the dry season. A typical analysis is given in Table 5.

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