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1984 PROGRESS REPORT

ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER

Contents

Preface x

Abbreviations and Acronyms xi

Horticultural Crops Program

Chinese Cabbage Breeding 3

Screening New Germplasm for Heat Tolerance 3
Combining Ability Trials 4
Stability of Entries in the Advanced Yield Trials 6
Further Improvement of ASVEG 1 11
Feasibility of Seed Blending for ASVEG 1 12
Hakuran Backcross Program 13
Heat Tolerance of Tropical Inbreds × Hakuran Backcross Derivatives 14
Cytosterility Backcross Program 15
International Trials 18

Chinese Cabbage Entomology 21

Screening Chinese Cabbage Germplasm for Resistance to Cabbage Webworm 21
Insecticide Screening for the Control of Cabbage Webworm 22
Influence of Intercropping on Diamondback Moth Infestation of Common Cabbage 23
Influence of Tomato Leaf Extract Spray on Diamondback Moth Oviposition 25
Sprinkler Irrigation for Diamondback Moth Control 27
Oviposition Behavior of Diamondback Moth 28
Screening of Insecticides for the Control of Diamondback Moth and Aphids on Common Cabbage and Chinese Cabbage 29

Chinese Cabbage Pathology 33

In-Vitro Testing of Chinese Cabbage Hybrids for Downy Mildew Resistance 33
Evaluation of the Inoculation Technique for Chinese Cabbage Soft Rot 36
Effect of Plant Density on Soft Rot of Chinese Cabbage 38
Screening of Germplasm for Resistance to TuMV Strains C_4 and C_5 39

Chinese Cabbage Physiology 41

Water Use of Heat-Tolerant and Heat-Sensitive Chinese Cabbage Plants 41

Tomato Breeding **43**

Crosses, Segregating Populations, and New Introductions 43
Evaluation of New Germplasm for Heat Tolerance 44
Diallel Analysis of Heat-Tolerant Parental Stocks 45
Yield Trial of New Tropical Breeding Lines 48
Yield Potential of Tropical Lines with Improved Drainage 52
International Trials 54

Tomato Entomology **59**

Fruitworm Resistance in Segregating Populations 59
Mass-Rearing and Sex Pheromone Studies on Tomato Fruitworm 60
Screening Hairy Tomato for Resistance to Aphids 61

Tomato Pathology **63**

Screening for Resistance to Cucumber Mosaic Virus 63
Hairy Tomato as a Source of Resistance to Cucumber Mosaic Virus 63
Screening for Resistance to Potato Virus Y (PVY) 65
Identification of an Unknown Virus on Tomato 66
Survey for PVY and the Unknown Isolate 697 and an Investigation of the Cause of Severe Necrotic Symptoms on Tomato 69
Tomato Leaf Mold (*Cladosporium fulvum*) 70
Testing Advanced Tomato Lines for Resistance to Leaf Mold, Early Blight, and Bacterial Spot 73
Evaluation of Sources of Resistance to Bacterial Spot in Tomato 74
Comparative Virulence of Different Isolates of *Corynespora cassiicola* 75
Studies on Bacterial Wilt of Tomato 76
Infectivity Titrations 77
Late Blight on Tomato 80

Tomato Physiology **83**

Effect of Temperature on the Stability of Tomato Flower Membranes 83
Effect of High Temperature on Protein Content in Tomato 85
Studies on Tomato Pollen Respiration 88
In-Vitro Study of Floral Bud Development 90
Evaluation of Morphological and Physiological Characters of Heat-Tolerant Tomatoes in a Multiple-Season Trial 92
Alternation of Endogenous Plant Hormones of the Tomato Fruit-Setting Process during Hot and Cool Seasons 97
Effect of Pollination on Fruit Set of Parthenocarpic and Seeded Tomatoes in Summer 100
Heat Tolerance of Parthenocarpic and Seeded Tomatoes in Hot Greenhouse Conditions 102
Inheritance in Parthenocarpic and Seeded Tomatoes under Hot Greenhouse Conditions 104

Processing Tomato Breeding **109**

Developing Heat-Tolerant and Disease-Resistant Processing Tomatoes 109
Inheritance Study of Heat-Tolerance in Parthenocarpic Tomato 115

Sweet Potato Breeding **123**

Hybridization 123
Seedling Screening and Observational Trials 123
Preliminary and Advanced Yield Trials in 1983 and 1984 125
Yield Stability in Multi-Locational Trials 129
Regional Yield Trial of Elite Sweet Potato Cultivars for Wet-Season Production in Taiwan 132
Selection of Cultivars for Animal Seed and Starch Production 134
Germplasm Collection 137
Germplasm Evaluation 138
International Cooperation 142

Sweet Potato Entomology **147**

Search for Germplasm Sources Resistant to Sweet Potato Weevil 147
Second Screening of Selected Sweet Potato Accessions for Resistance to Sweet Potato Vine Borer at Penghu Island 148

Sweet Potato Pathology **151**

Survey of Sweet Potato Viruses in AVRDC Fields and Evaluation of the Survey Method 151
Virus Indexing of Meristem-Derived Sweet Potato Plantlets 152

Sweet Potato Physiology **155**

Production of Small Virus-Free Sweet Potato Storage Roots by Meristem-Tip Culture and Leaf-Cutting 155
Influence of Leaf Age and Petiole Length in Storage Root Formation of Sweet Potato Leaf-Cuttings 157
Responses of Sweet Potato Leaf-Cuttings to Drought 159

Legume Crops Program

Mungbean Breeding **165**

Germplasm Collection 165
Germplasm Evaluation 165
Crossing Program 167
Preliminary, Intermediate, and Advanced Yield Trials 168

Performance of Breeding Lines under Minimum Management Input.....174
Evaluation of Breeding Lines in Various Yield Trials for Disease Resistance.....177
Photoperiodic Response of Breeding Lines.....179
International Cooperation.....181

Mungbean Entomology.....185

Third Screening of Mungbean Accessions for Resistance to Beanflies.....185
Screening of Segregating Populations for Resistance to Beanflies.....186
The Mechanism of Beanfly Resistance in Selected Mungbean Accessions.....187
Screening of Interspecific Cross Segregating Materials for Resistance to Bruchid.....189

Mungbean Pathology.....193

Screening for Resistance to Three Unknown POT-Y Virus Isolates and to CMV.....193
Further Studies Towards the Identification of Three POTY Virus Isolates.....194
Greenhouse Seedling Screening for Resistance to Powdery Mildew.....196

Soybean Breeding.....201

Germplasm Collection.....201
Evaluation of Germplasm.....202
Hybridization Program.....204
Breeding for Photoperiod Insensitivity.....204
Yield Potential of Photoperiod-Insensitive Accessions.....205
Preliminary and Intermediate Yield Trials.....206
Preliminary Yield Trial for Vegetable Soybean.....211
Mutation Breeding.....212
Advanced Yield Trials.....214
Continuous Soybean Cropping.....216
Genotypic Variation for Shade Tolerance in Soybean.....217
Sole-Cropping Compared to Intercropping.....220
Response to Minimum and Maximum Management Inputs.....221
International Cooperation.....222

Soybean Entomology.....231

Preliminary Screening of Soybean Germplasm for Resistance to Beanfly (mainly *Ophiomyia phaseoli* in Indonesia.....231
Preliminary Screening of Additional Soybean Accessions for Resistance to Beanfly (mainly *M. sojae*) at AVRDC.....232
Third Screening of Selected Soybean Accessions for Resistance to Beanflies.....233
Beanfly Infestation and Soybean Yield under Natural Autumn and Extended Photoperiods.....234
Resistance Mechanism of Selected Soybean Accessions to *Porthesia taiwana*.....236
Antibiosis of Selected Soybean Accessions to Scarabid Beetles.....237
Screening of Soybean Accessions for Resistance to Lima Bean Pod Borer.....239

Soybean Pathology **241**

Preliminary Rust Tolerance Trials 241
Intermediate Soybean Rust Tolerance Trial, Spring 1984 242
Advanced Soybean Rust Tolerance Trial, Spring 1984 244
Rust Tolerance Trial in Thailand 246
Rust Tolerance Trial in Hualien DAIS, Spring 1984 248
Efficiency of Five *Phakopsora pachyrhizi* Biocontrol Agent under Field Conditions 250
The Effect of Different Fungicide Spray Schedules on Two Soybean Cultivars with Rust Tolerance 251
Screening for Bacterial Pustule Resistance 253
The Relationship between Seed Weight, Seed-Borne Diseases, and Germination of Soybean AGS Lines Harvested in Summer 1984 255
Effect of Benomyl Spray Schedules on Seed Quality of Soybeans Grown during Spring and Summer 1984 258
Effect of Seed Treatment on Germination of Soybean 259
Infection of Rice Seedlings by VAM Fungi 261
Further Identification of Unknown Soybean Virus Isolates 262
Screening of Selected AGS Lines, AGS Parents, and Soybean Accessions for Resistance to an Unknown Soybean Virus 263
Survey for Soybean Mosaic Virus (SMV) and an Unknown Virus in Taiwan 265
Detecting Soybean Mosaic Virus Strains 266
Detection of Seed-Transmitted SMV after Seed Storage 267

Nutrition, Environment, and Management

Agricultural Economics **271**

Processing Tomato Production in Taiwan 271
Farmers' Responses to Two Processing Tomatoes 276
Responses of Factories to a New Tomato Cultivar 281
The Responsibility and Financial Position of Tomato Farmers' Representatives in Taiwan 283
Farmers' Viewpoint on the Production of Summer Chinese Cabbage in the Lowlands of Taiwan 285
Prices of Selected Types of Summer Chinese Cabbage 288
Causes of Price Differentiation between Two Selected Types of Chinese Cabbage 290
Shopping Behavior of Chinese Cabbage Consumers 292

Crop Management **295**

Effect of Leaf-Tying Time and Daminozide on Summer Chinese Cabbage 295
Herbicide Screening for Transplanted Chinese Cabbage 297
Herbicide Screening for Transplanted Tomato 299
Effect of Spacing on Growth and Yield of Tomato 301

Effect of Population Density and Row Spacing on Soybean Yield....302
Herbicide Evaluation for Soybean....304
Herbicide Evaluation for Mungbean....305

Garden Program....309

School Garden....309
Home Garden....311
Market Garden....312
Other Activities....313

New Vegetable Project....337

Evaluation of Commercial Cultivars of Five Vegetable Crops....337

Nutrition Chemistry....349

Sprouting Properties of Small-Seeded Soybean....349
Effect of Sweet Potato Starch on Digestibility and Feeding Efficiency of Dietary Protein....352
New Infrared Reflectance Spectroscopy for Compositional Analysis of Soybean, Mungbean, and Sweet Potato....354
Preliminary Studies on Optimum Beaneurd-Skin Processing Conditions....356
Flatulence Induced by Sweet Potato....359

Soil Microbiology....363

Developing a Garden Compost Bed....363
Producing Small Quantities of Legume Inoculant Cheaply....365
Effectiveness of Fast-Growing *Rhizobium japonicum* Strains Isolated from Nodules Collected in Vietnam....366
Effect of the Interaction between *Rhizobium japonicum* Strains and *Azotobacter* Spp. on Soybean Growth and Nodulation....368
Illustrated Reference Cards for Identifying Nutrient Deficiencies and Diseases in Tomato....368

Soil Science....371

Effect of Nitrogen Fertilization on Soybean Growth....371
Evaluation of Symbiotic Nitrogen Fixation of Soybean Isolines....374
Rational Nitrogen Fertilization for Soybean....384
Effect of Time, Form, and Concentration of Nitrogen Application on Chinese Cabbage Tipburn....385
Effect of Soil Depth and Suppression of Transpiration from the Outer Leaves of Chinese Cabbage on Tipburn and Internal Rot....393
Effect of Covering and Foliar Spray on Chinese Cabbage Tipburn and Internal Rot....397

Tomato and Chinese Cabbage Cultivation on a High Bed....400
Characterizing the Major Soil Groups in the Tropics according to Their Yield Potential....402
Effect of pH, EC, and Nutrient Status of AVRDC Soil on Crop Yield....406

Training, Conservation, and Information Services

Training and Development Office....413

Training Program....413
Development Program....414

Genetic Resources and Seed Unit....435

The Status of the AVRDC Germplasm Collection....435
Germplasm Seed Inventory and Regeneration....436
Seed Distribution....436
New Building Construction and Equipment....438
AVRDC/IBPGR Joint Projects....440

Office of Information Services....457

Appendix

Board of Directors....463
Finances....465
Germplasm Recipients....466
Publications Available....471
Seminars....477
Senior Personnel....478

Preface

This publication provides detailed reports on the research conducted at the Asian Vegetable Research and Development Center (AVRDC) during the 1984 calendar year. Because of the expense involved in its production, it will be distributed free of charge only to libraries. Personal copies can be purchased for US $10.00 (please see "Publications Available" for instructions.) Readers who need only general information about AVRDC research are invited to request a complimentary copy of the Center's 1984 Progress Report Summaries.

All requests should be sent to the AVRDC Office of Information Services, P.O. Box 42, Shanhua, Tainan 74199, Taiwan.

Abbreviations and Acronmys

a.i. — active ingredient
ARRT — advanced rust tolerance trial
ASET — AVRDC soybean evaluation trial
AVRDC — Asian Vegetable Research and Development Center
AYT — advanced yield trial
AzMV — adzukibean mosaic virus
BARI — Bangladesh Agricultural Research Institute
BCMV — bean common mosaic virus
BGMV — bean golden mosaic virus
BICMV — blackeye cowpea mosaic virus
BIMV — blackgram mottle virus
BLS — bacterial leafspot
BV — biological value
BW — bacterial wilt
BYMV — bean yellow mosaic virus
CAMV — cowpea aphid-borne mosaic virus
CAT — combining ability trial
cc — cubic centimeter
CCMV — cowpea chlorotic mottle virus
CFU — colony forming units
CGR — crop growth rate
CLS — *Cercospora* leafspot
cm — centimeter
CMV — cucumber mosaic virus
CMV-Y — cucumber mosaic virus-Y
CPATU — Centro de Pesquisa Agropecuaria Tropico Umido
CPA — 4-chlorophenooxyacetic acid
CPMV-S — cowpea mosaic virus S
CPMV-Y — cowpea mosaic virus Y
CV — coefficient of variance
cv — cultivar
CMS — cytoplasmic male sterility
DAE — days after emergence
DAG — days after germination
DAP — days after planting
DAT — days after transplanting
DNP — dinitrophenol
ELISA — enzyme-linked immunosorbent assay
EMBRAPA — Empresa Brasileira de Pesquisa Agropecuaria
EYT — elite yield trial
FAO — UN Food and Agriculture Organization
FE — feeding efficiency
FMV — feathery mottle virus
g — gram
ha — hectare
HGR — height growth rate
HI — harvest index
HR — highly resistant
HS — highly susceptible
IAAS — Institute of Agriculture and Animal Science
IARI — Indian Agriculture Research Institute
IBPGR — International Board for Plant Genetic Resources
ICA — Instituto Colombiano Agropecuario
i.d. — inside diameter
IITA — International Institute of Tropical Agriculture
IMN — International Mungbean Nursery
INRA — Institute national de la recherche agronomique
INTSOY — International Soybean Program
IRAT — Institut de recherches agronomiques tropicales et des cultures vivrieres
IRRI — International Rice Research Institute
IRTT — intermediate rust tolerance trial
ISEM — immunosorbent electron microscopy
IYT — intermediate yield trial
kg — kilogram
LAD — leaf area duration
LAI — leaf area index
LER — leaf area expansion rate
m — meter
min — minute
ml — milliliter
mm — millimeter

MR — moderately resistant
MS — moderately susceptible
NAR — net assimilation rate
NIAS — National Institute of Agricultural Science
NIRS — near infrared reflectance spectroscopy
NSC — National Science Council
NSSL — National Seed Storage Laboratory
NT$ — New Taiwan Dollar
NTU — National Taiwan University
OYT — observational yield trial
PER — protein efficiency ratio
PDA — potato dextrose agar
PM — powdery mildew
PMV — peanut mosaic virus
ppm — parts per million
PRTT — preliminary rust tolerance trial
psi — pounds per square inch
PSV — peanut stunt virus
PSV-B — peanut stunt virus B
PvF — polyvinyl formate
PVX — potato virus X
PVY — potato virus Y
PYT — preliminary yield trial
PeMV — pepper mottle virus
R — resistant
RB — reddish-brown
RCB — randomized complete block
RDA — recommended dietary allowance
RDW — root dry weight
RGR — relative growth rate
RH — relative humidity
S — susceptible
SARIF — Sumatra Agricultural Research Institute for Food Crops
SBMV — southern bean mosaic virus
SHAM — hydroxamic acid
SLW — specific leaf weight
SMV — soybean mosaic virus
SPD — split plot design
SPV-A — sweet potato virus A
SPV-N — sweet potato virus N
SSV — soybean stunt virus
t — metric ton
TARI — Taiwan Agricultural Research Institute
TEV — tobacco etch virus
TLCV — tomato leafcurl virus
ToMV — tomato mosaic virus
TOP — Thailand Outreach Program
TSWV — tomato spotted wilt virus
TYDV — tomato yellow dwarf virus
TuMV — turnip mosaic virus
TYLCV — tomato yellow leafcurl virus
USAID — United States Agency for International Development
USDA — United States Department of Agriculture
VAM — vesicular arbuscular mycorrhizae
ViSCA — Visayas State College of Agriculture
WAP — weeks after planting
WAT — weeks after transplanting
WP — wettable powder

Horticultural Crops Program

Chinese Cabbage Breeding

Screening New Germplasm for Heat Tolerance

Introduction

All newly acquired germplasm routinely passes through the evaluation process for heat tolerance and other important traits. In the 1983 summer season, a number of such accessions were evaluated and some were rated as tentatively heat tolerant because the time of evaluation was already close to the cool season. These accessions, along with others that had not been tested, were planted in the 1984 summer season for confirmation of their heat tolerance.

Materials and Methods

A total of 15 accessions were sown on June 6 and transplanted on June 27 to assess for heat tolerance. The design was randomized complete block with two replications. Individual plots consisted of two rows, each 4 m long and spaced 50 cm apart within the double-row bed. Spacing between plants within the row was 40 cm apart. Heat tolerance was judged from the percentage of the plants forming dense heads within an entry. Data on yield and other horticultural characters were gathered later to compare them with the standard check, ASVEG 1.

Results

Of 15 entries tested, three were rated heat tolerant. These accessions and their horticultural characters are listed in Table 1. The results were not statistically treated because many accessions did not form heads and cannot be treated as missing plots. The new heat-tolerant accessions were comparable to ASVEG 1 in terms of heading rate (100%), but harvest rates varied because some accessions, especially B812, proved to be susceptible to soft rot. ASVEG 1 was still the earliest maturing and had the least soft rot infection among entries.

Table 1. Comparison of yield and other horticultural characters between the new heat-tolerant accessions and the standard check, ASVEG 1 (AVRDC 1984).

Acc No./Cultivar	Marketable Yield (t/ha)	Days to Maturity	Head Weight (g)	Heading Rate (%)	Harvest Rate (%)	Soft Rot (%)
B808	16	50	525	100	91	8
B812	10	44	414	100	69	30
Summer Sun	17	44	502	100	100	11
ASVEG 1 (Check)	14	41	422	100	100	2

Conclusion

Three new accessions were found to be heat tolerant. At least one of these, cv. Summer Sun, yielded well and had 100% heading and harvest rates. The new accessions tended to

be later maturing and seemed more prone to soft rot attack than ASVEG 1. The use of these accessions in the breeding program depends upon whether they possess other important characteristics apart from heat tolerance. These will await further studies.

Combining Ability Trials

Introduction

The search for better tropical hybrid combinations continued in 1984. Basically, our standard for comparison on yield and other characters has been ASVEG 1. In the last two years, no combination superior to ASVEG 1 in overall performance has been found. Selection of new combinations has been limited mainly to other aspects of cultivar acceptability, such as smooth leaf surface texture, absence of hair, relative resistance to tipburn where this was possible, and reduced midrib cracking.

Materials and Methods

A total of 47 new hybrid combinations was made in the 1983-84 winter season for testing on "nicking ability" in the 1984 summer. These new hybrids were sown on August 9 and seedlings were transplanted on August 29. The design was randomized complete block with two replications. Each plot consisted of two 4-m-long rows in a double-row bed, with rows spaced 50 cm apart and plants within the row, 40 cm apart. The test included ASVEG 1 as the standard check. We also included in this trial an older form of ASVEG 1 for further comparisons. Yield and other horticultural characters were measured.

A large set of crosses between a few lines derived from the TuMV backcross program (resistance to strain C1) and tropical inbred lines were also tested. Batch I consisted of 65 crosses compared against ASVEG 1. This batch was sown on May 23 and transplanted on June 13. Batch II was made up of 53 crosses tested also against ASVEG 1. This set was sown on June 18 and transplanted on July 9. Design in both experiments was randomized complete block with two replications. Individual plots consisted of two 4-m-long rows in a double-row bed, with rows within beds spaced 50 cm apart and plants within the row, 40 cm apart. Yield and other horticultural characters were measured.

The most outstanding combinations were immediately selected from the above trials for further tests. As a result, two additional plantings were carried out. The first set (Batch III) consisted of 22 entries (or combinations) tested against ASVEG 1. The second set (Batch IV) consisted of 24 entries compared also with ASVEG 1. Both trials were sown on August 31 and transplanted on September 20. The design in both trials was randomized complete block with two replications. Plot size and spacing were similar to the earlier experiments from which the entries were derived. Yield and other horticultural characters were measured and compared with the check.

Results

No combination among the first set of 47 crosses clearly outperformed ASVEG 1. Some combinations that were comparable to ASVEG 1 in yield and other horticultural characters were selected, however, for their better overall general appearance. These entries are listed in Table 2 with their yield and other traits compared with ASVEG 1. The older form of ASVEG 1 did not prove to be superior to the present form of the hybrid.

Five combinations significantly outyielded and produced heavier heads than ASVEG 1 in the Batch I trial (Table 3). With the exception of # 52, most matured later than ASVEG 1. Compactness (solidity) of the heads of all new combinations was comparable to ASVEG 1. All listed entries had no soft rot infection.

In the Batch II test, none significantly outyielded ASVEG 1 (Table 4). Most entries, except # 42, matured as early as ASVEG 1. Generally, maturity of most entries was earlier than in Batch I. The best entries had minimal soft rot infection (range = 0 to 3%).

In the Batch III trial, five entries were clearly superior to ASVEG 1 in yielding ability and average head weight (Table 5). One combination, # 13, was also superior to ASVEG 1 in the earlier trial. It is significantly later maturing than the latter, however. Yields among the best entries ranged from 24 to 26 t/ha. Again, there were no appreciable differences between entries in head compactness, as well as heading and harvest rates. All listed entries, including ASVEG 1, showed no soft rot infection in this test.

Two combinations gave significantly higher yield and heavier head than ASVEG 1 in the Batch IV trial (Table 6). One of these, # 21, had the highest yield of 30 t/ha in this trial and was also superior to ASVEG 1 in an earlier trial. Another entry, # 19, was also better than ASVEG 1 in an earlier trial although its yield of 24 t/ha in this test did not substantially differ from that of ASVEG 1 (18 t/ha). The maturity of the best Batch IV entries was not markedly different from that of ASVEG 1 as were their heading rates, harvest rates, and head solidity. All listed entries also showed no soft rot infection.

Table 2. Yield and other horticultural characters of the best entries as compared with ASVEG 1 in the combining ability trial.

Cross No.	Yield (t/ha)	Days to Maturity	Head Weight (g)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
11	19	37	580	97	100	10
12	19	40	556	100	100	3
ASVEG 1	15	39	451	100	100	5
CV[z] (%)	15	5	13	12	7	49

[z] CV = Coefficient of variation.

Table 3. Yield and other horticultural characters of the best combinations in the combining ability trial (Batch I) of crosses between lines from the TuMV backcross program and the tropical inbreds.

Entry No.	Yield (t/ha)	Days to Maturity	Head Weight (g)	Solidity (g/cc)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
57	29 a	41 a	834 bc	.55	100	100	0
54	29 a	41 a	867 ab	.61	100	100	0
19	27 ab	41 a	806 b-d	.59	100	100	0
52	26 a-c	36 b	777 b-f	.52	100	100	0
49	25 a-d	41 a	759 b-h	.52	100	100	0
ASVEG 1	20 f-j	36 b	589 i	.55	100	100	0
CV(%)	10	5	10	13	8	2	+[z]

[z] CV of more than 100%.

Table 4. Yield and other horticultural characters of the best combinations in the combining ability trial (Batch II) of crosses between lines from the TuMV backcross program and the tropical inbreds.

Entry No.	Yield (t/ha)	Days to Maturity	Head Weight (g)	Solidity (g/cc)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
42	26	37	774	.49 b	100	100	0
9	26	30	765	.50 a	100	100	3
21	25	34	750	.51 a	100	100	3
52	25	34	750	.52 a	100	100	3
4	25	30	746	.53 a	100	100	3
ASVEG 1	24	30	730	.53 a	100	100	0
CV(%)	12	5	10	9	9	3	+

Table 5. Yield and other horticultural characters of the best combinations in the combining ability trial (Batch III) of crosses between lines from the TuMV backcross program and the tropical inbreds.

Entry No.	Yield (t/ha)	Days to Maturity	Head Weight (g)	Solidity (g/cc)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
17	27	42 b-d	795 a	.63	100	100	0
13	25	45 ab	781 ab	50	97	100	0
16	24	40 cd	730 a-c	.64	100	100	0
8	24	39 cd	720 a-c	.56	100	100	0
10	24	37 d	719 a-c	.57	100	100	0
ASVEG 1	16	39 cd	491 de	.64	100	100	0
CV(%)	14	6	13	12	5	0	+

Table 6. Yield and other horticultural characters of the best combinations in the combining ability trial (Batch IV) of crosses between lines from the TuMV backcross program and the tropical inbreds.

Entry No	Yield (t/ha)	Days to Maturity	Head Weight (g)	Solidity (g/cc)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
21	30 a	45 a-c	903 b	.50	100	100	0
14	26 ab	47 ab	791 bc	.62	100	100	0
19	24 bc	45 a-c	728 cd	.59	100	100	0
23	23 b-d	45 a-c	696 c-e	53	100	100	0
15	23 b-d	47 ab	690 c-f	.62	100	100	0
• ASVEG 1	18 c-j	43 a-c	537 f-i	.62	100	100	0
CV(%)	14	6	11	13	3	2	+

Conclusion

A total of 165 new combinations were tested against the standard check, ASVEG 1, in five different sets of combining ability trials in 1984. None of the new hybrids in the first set was clearly superior to ASVEG 1. However, some were selected for further tests based on their better overall appearance. A number of superior hybrids of lines derived from the TuMV backcross program and crossed with the older tropical inbreds proved markedly better than ASVEG 1 in a series of related tests. The best new combinations will be retested in the 1985 summer season.

Stability of Entries in the Advanced Yield Trials

Introduction

Over the years, the tropical Chinese cabbage program has performed a selection process to search for genotypes with stable performance over a reasonable range of environmental vicissitudes even before the new genotypes are entered in the regional testing network within Taiwan. Through a series of plantings from the beginning to the end of summer, it is possible to establish varying environmental indices; the performance of entries in these trials may be analyzed for stability of yield and other important characters. Only the relatively stable entries are then recommended for inclusion in the regional trials.

In the tropical Chinese cabbage program, the ideal stable genotype is normally defined as "one which yields better than the average throughout the summer, has 100% heading rate implying complete heat tolerance, and has 100% harvest rate which indicates that soft rot infection and other damaging factors associated with the adverse environment do not have any significant influence on that genotype"

Materials and Methods

A total of eight plantings of entries in the advanced yield trial was made in the 1984 summer. Sowing and transplanting dates are given below:

Trial Number	Sowing Date	Transplanting Date
I	5/11	6/2
II	5/25	6/15
III	6/8	6/28
IV	6/22	7/12
V	7/10	7/31
VI	7/25	8/18
VII	8/9	8/29
VIII	8/24	9/14

The design in all plantings was randomized complete block with four replications. Individual plots consisted of four rows in two double-row raised beds. Each row was 4 m long and spaced 50 cm apart within the bed. Plants within the row were 40 cm from each other. Yield and other horticultural characters were measured in the trials.

After the standard analysis of variance of each trial, a further analysis of stability using the method proposed by Eberhart and Russell* was carried out for yield, head weight, maturity, heading rate, and harvest rate. The standard statistical measures of stability for these traits were given in the 1983 report. For other traits, stability analyses were not carried out, but comparisons across plantings were made among selected entries to see certain trends.

Results

Table 7 shows the means and stability parameters (regression coefficient and standard deviation from regression) for marketable yield, head weight, and maturity. Three entries indicated unstable performance across the range of summer environments: WWCC (one of the checks), 82-50, and 82-50R. In several cases, these entries had regression coefficients significantly different from unity (b = 1) and/or significant deviations from their respective regression lines. In contrast, six entries were stable as indicated by their regression coefficients that were statistically equal to 1 and deviations of their means from corresponding regression lines that were insignificant.

Table 7. Means and stability parameters for selected characters of entries in the advanced yield trials (AVRDC 1984).[z]

Entry	Yield[y]			Head Weight[y]			Maturity[y]		
	mean	b	S^2d	mean	b	S^2d	mean	b	S^2d
82-46	18.1	1.3	8.3	624	1.2	3095	40	1.1	1.6
82-46R	19.0	1.4	2.9	655	0.9	2230	40	1.0	2.0
82-50	19.3	1.8**	2.6	678	1.5*	1946	41	1.3**	0.6
82-50R	19.9	1.6**	0.7	691	1.3*	643	40	1.1	2.4
82-82	19.3	0.8	2.1	640	1.0	3338	39	0.7	2.8
82-156	17.8	0.8	4.7	550	0.9	1622	40	0.8	1.2
82-157	17.4	0.8	4.5	532	0.8	1716	40	0.8	2.5
ASVEG 1(ck)	18.0	0.9	3.7	567	0.8	1094	38	0.8	1.4
WWCC (ck)	15.9	0.1**	15.4**	718	0.7	8448*	47	1.2	4.8
Grand mean	17.6	–	–	616	–	–	40	–	–

[z]b = regression coefficient. S^2d = deviation from regression. [y]Test for significance of regression coefficient (b) is against H0: b = 1. * = significant at P = .05; ** = significant at P = .01.

* A Eberhart, S.A. and W.A. Russell. 1966. Stability parameters for comparing varieties. Crop Science 6:36-40.

When viewed from the standpoint of heading and harvest rates, the number of stable entries was reduced to only one (82-156). For all practical purposes, however, three other entries such as 82-82, 82-157, and ASVEG 1 may be considered relatively stable, as they showed instability for only a single trait and; in all cases, the deviations from the desired parameter values were significant only at P = 0.05 (Table 8). Invariably, all unstable entries, including the check WWCC, had regression coefficients for harvest rates that were much higher than the desired level (b = 0). This indicates that the proportion of harvests on these hybrids varied greatly, tending to be low under the most adverse environment but better than the average as the environment improved. Since all unstable entries, except WWCC and 82-50R, had stable heading rates, the instability of their harvest rates must have been brought about by varying soft rot infection levels in the different trials. Evidence in this regard is given for WWCC in Table 9.

Figs. 1, 2, and 3 depict the regression lines of some of the entries for yield, heading, and harvest rates, respectively, for comparative purposes. As may be noted in Fig. 1, 82-156 had a regression line near the average with points fairly close to it. Under the poorer environment, this hybrid tended to yield slightly better than most other entries but in better environments performed less than the average. In contrast, 82-50R gave a steep regression line, indicating that in poor environment it performed very poorly but improved over the average when the environment was most suitable. The spread of its points from the theoretical regression line was also evident.

Table 8. Means and stability parameters for selected characters of entries in the advanced yield trials (AVRDC 1984).[z]

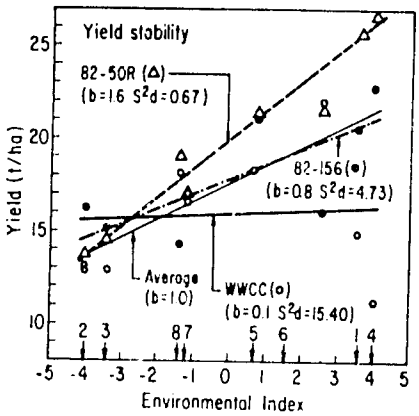
Entry	Heading Rate[y]			Harvest Rate[y]		
	mean	b	S^2d	mean	b	S^2d
82-46	89	0.6	2.5	72	1.2**	31
82-46R	90	0.2	0.5	74	1.2**	19
82-50	87	0.5	11.2	71	1.2**	17
82-50R	85	2.0*	11.0	72	1.4**	28
82-82	88	0.7	8.8	76	0.8*	35
82-156	90	0.6	1.5	84	0.2	13
82-157	89	-0.5*	0.6	85	0.1	7
ASVEG 1(ck)	90	0.2	0.5	81	0.6*	27
WWCC (ck)	63	5.4**	33.0**	58	1.6**	49
Grand mean	86			73		

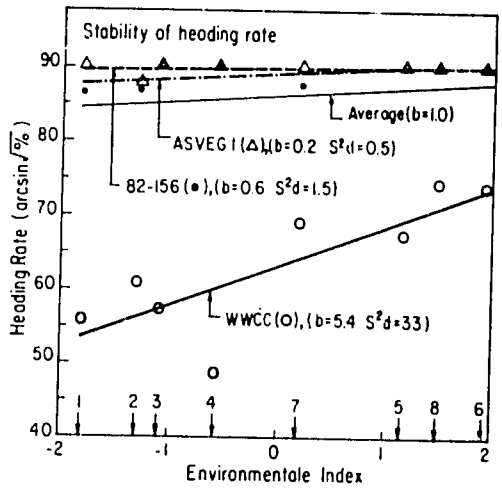
[z]b = regression coefficient, S^2d = deviation from regression. [y]Percentages are transformed to arcsin $\sqrt{\%}$ and test for significance of regression coefficient (b) is against H0: b = 0. * = significant at P = .05; ** = significant at P = .01.

Table 9. Comparative soft rot infection levels (%) among stable hybrids and check cultivars.[z]

Trial Set	82-156	82-157	ASVEG 1 (ck)	WWCC (ck)	CV(%)
I	4 d	2 e	3 d	20 a	23
II	1 e	2 e	8 d	28 a	30
III	1 e	3 e	4 e	15 a	25
IV	4 d	3 d	9 b	11 b	29
V	3	2	2	9	49
VI	2	0	2	2	21
VII	5 e	4 e	12 c	14 c	21
VIII	0 c	1 c	1 c	6 a	116
Grand mean	3	2	5	13	

[z]Multiple range test comparison of means is across columns (within trial).





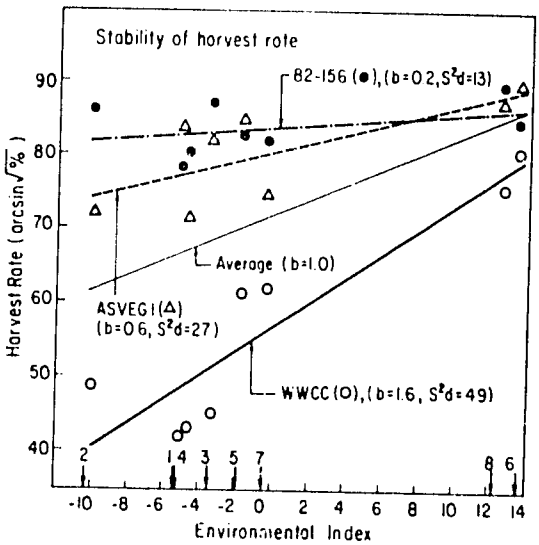


Fig. 1. (upper left)
Comparative stability of yield across environments of three advanced yield trial entries, AVRDC 1984.

Fig. 2. (upper right)
Comparative stability of heading rate across environments of three advanced yield trial entries, AVRDC 1984.

Fig. 3. (left)
Comparative stability of harvest rate across environments of three advanced yield trial entries, AVRDC 1984.

WWCC gave a relatively flat regression line, implying that regardless of the environment it performed similarly. However, the deviation of its points from the line was highly significant making it rather unstable. Moreover, the line was not well above the average regression, which means that under the more favorable environments, this variety would be greatly outyielded by other entries.

For heading rate, the ideal entry is one with a relatively flat regression line at or close to 100% (or value of arcsin $\sqrt{\%} = 90$). This trend was evident on 82-156 and ASVEG 1 (Fig. 2). In contrast, moderately heat tolerant WWCC had a regression coefficient well over the ideal zero with most of the points spread away from that line. In the case of harvest rate (Fig. 3), 82-156 also gave the flattest line close to the ideal level (arcsin $\sqrt{\%} = 90$), indicating that throughout the summer its harvest proportions were consistently high. ASVEG 1 also appears fairly stable in this regard. On the other hand, WWCC had a regression coefficient that was highly significant from the ideal zero value.

Tables 9, 10, 11, and 12 further compared the stable entries against the most unstable WWCC for soft rot infection, solidity of head, heading efficiency, and vigor (expressed as weight of nonwrapper leaves), respectively. Clearly, the stable entries 82-156 and 82-157 along with ASVEG 1 had consistently lower soft rot infection levels than WWCC. The latter had variable infection rates, tending to be high especially during the early summer and lower in later plantings, except in Trial VII when all entries had higher damage. Solidity of heads was

nearly similar for the stable entries as compared to ASVEG 1, and all three tended to be better than WWCC especially in Trials III and IV.

In terms of heading efficiency, ASVEG 1 had the best values while WWCC had the lowest, implying that the latter tended to produce heavier non-wrapper leaves relative to its heads. In almost all cases, the differences among the entries were significant except in Trial II. The foregoing results are further supported by the data on vegetative vigor. WWCC had the heaviest nonwrapper leaves throughout the trials. In contrast, the heat-tolerant stable entries and ASVEG 1 generally produced only a little more than half as much vegetative growth. This is true for nearly all trials except Trial IV.

Conclusion

A series of advanced yield tests in summer 1984 enabled the identification of three new hybrids with stable performances throughout the range of summer environments. ASVEG 1,

Table 10. Comparative solidity (g/cc) of the stable hybrids and the check cultivars.

Trial Set	82-156	82-157	ASVEG 1 (ck)	WWCC (ck)	CV(%)
I	.50	.54	.61	.42	15
II	.45	.54	.50	.40	16
III	.45 a	.48 a	.47 a	.36 d	10
IV	.55 a	.52 a	.58 a	.41 b	11
V	.56	66	.56	.47	13
VI	.48 b	.56 b	.68 a	.47 b	2
VII	.49	.51	.51	.41	11
VIII	.50	.46	.53	.58	14
Grand mean	.50	.53	.55	.44	

Table 11. Comparative heading efficiency of the stable hybrids and the check cultivars.

Trial Set	82-156	82-157	ASVEG 1 (ck)	WWCC (ck)	CV(%)
I	.94 ef	82 fg	1.04 e	.78 g	10
II	.75	.78	.72	.65	13
III	.58 c	.70 b	.70 b	.64 bc	8
IV	1.12 b	1.21 b	1.53 a	.97 b	11
V	.95 ab	.81 bc	.85 ab	.67 c	13
VI	.84 de	.84 de	1.03 bc	.75 e	10
VII	.80 d	.87 d	.99 c	.62 e	9
VIII	.85 c	.85 c	.92 c	.66 e	5
Grand mean	.85	.86	.97	.64	

Table 12. Comparative vigor (nonwrapper leaf weight) of stable hybrids and the check cultivars.

Trial Set	82-156	82-157	ASVEG 1 (ck)	WWCC (ck)	CV(%)
I	700 c	759 c	741 c	1274 a	9
II	661 b	601 b	695 b	1050 a	11
III	791 b	680 c	727 bc	1174 a	10
IV	637 ab	563 bc	442 de	724 a	12
V	734 b	724 b	662 b	1054 a	11
VI	578 c	595 c	530 c	931 a	9
VII	643 b	592 c	536 c	1048 a	9
VIII	504 f	482 f	511 f	909 a	6
Grand mean	656	625	606	1021	

the standard heat-tolerant check, was also fairly stable; WWCC, the other check, proved to be the most unstable. The average yields of these new hybrids, 82-156 and 82-157, were only slightly better than the average, however. Their main advantage over ASVEG 1 is in overall appearance, as they have smoother leaf texture, are hairless, and more erect.

Under severe heat and moisture stress of summer, they maintained more turgidity than most other entries, including ASVEG 1. Since these new hybrids tended to have thrifty growth like ASVEG 1, it could be worthwhile to explore population density as a means to maximize per unit area yield. The stable entries will be entered in the 1985 regional trial for further comparisons with local commercial hybrids.

Further Improvement of ASVEG 1

Introduction

In the course of further testing of ASVEG 1 during the past two years, it has been recognized that smooth leaf character is a desirable trait for the hybrid to possess. The original ASVEG 1 possessed this trait to some extent, but a slight change took place during its previous seed production cycles. ASVEG 1 now appears to be more dark green with finely puckered leaves, but seems more tolerant to stress and diseases, especially soft rot.

In addition, we have been able to isolate strongly self-incompatible types from its male parent instead of only from the female side. This will make seed production more economical, as seed blending may now be feasible (see next section on this aspect). Nonetheless, consumer preference is apparently for smoother leaves during the summer; and thus, we decided to recapture the smooth-leaf form of the hybrid. Female sibs from old seed lots of ASVEG 1 were recovered and crossed with different male parent plants.

Materials and Methods

A total of 50 crosses or entries were compared to the original and newer version of the hybrid for a number of horticultural characters. Entries were sown on June 26 and transplanted on July 17. Another batch was sown in the middle of the summer on July 25 and transplanted on August 20. At about heading time, when the morphological dissimilarities between the two forms usually become apparent, each cross was observed for their resemblance to either of the two hybrid forms. Yield and other horticultural characters were measured later.

Results

All the new crosses designed to search for less crinkled form of ASVEG 1 did not differ morphologically from the latter. In terms of yield and other measurable characteristics, there were no significant differences between the new crosses and ASVEG 1 in the first trial, except in overall vegetative growth and level of soft rot infection (Table 13). No further measurement of yield and other characters was done in the second trial when it became apparent that the entries were not different morphologically from ASVEG 1. Since growth did not seem to affect yield itself, no further selection for a replacement to ASVEG 1 was made. Soft rot infection level, another character that showed considerable variation among entries despite the high coefficient of variation (50%), was not considered either, since the rate of the least infected cross did not significantly differ from that of ASVEG 1.

Conclusion

Further intercrosses of sibs within ASVEG 1 did not alter the general morphology of the hybrid. The slight changes observed among the intercrosses did not warrant replacing the present form of ASVEG 1. Although the present form has the disadvantage of having relatively

puckered leaves, the possibility of economically producing its seeds and the stability of its performance throughout the summer more than make up for this limitation. These aspects are discussed in their respective sections in this report.

Table 13. Summary of the analyses of variance for various characters of crosses designed to improve ASVEG 1 (AVRDC 1984).

Criteria	Yield (t/ha)	Days to Maturity	Head Wt (g)	Growth (g)	HER[z]	Heading Rate (%)	Harvest Rate (%)	Soft Rot (%)
Significance	ns	ns	ns	*	ns	ns	ns	*[y]
CV(%)	21	4	15	11	14	6	13	50

[z]Heading efficiency ratio [y]Lines with least soft rot infection did not differ significantly from that of ASVEG 1 (7%).

Feasibility of Seed Blending for ASVEG 1

Introduction

One economical way of producing hybrid seeds is to harvest them from both parents and blend them for commercial distribution. In the past, we harvested ASVEG 1 seeds only from the female line which possessed a strong self-incompatible allele. In contrast, incompatibility on the male line has been practically absent until two years ago when we succeeded in isolating relatively strong allele from its sibs.

Results from our studies since then indicated that differences, if any, were negligible between F1 progenies derived from male and female line (see previous reports). This year we extended this investigation to make an unequivocal conclusion on whether seed blending is possible in the seed-multiplication of ASVEG 1.

Materials and Methods

Three kinds of seeds were used in this experiment, as follows: direct cross seeds, or seeds harvested from the regular female parent, E7; reciprocal seeds, or seeds harvested from the regular male parent, B18; and blended seeds constituted from a 1:1 mixture of direct and reciprocal seeds.

All seed types were sown on July 25 and seedlings were transplanted on August 20. The experimental design was randomized complete block with four replications. Individual plots consisted of two rows, each 4 m long and spaced 50 cm apart within the double-row raised bed. Plants within the row were spaced 40 cm apart.

Prior to transplanting, seedlings of each type were observed for frequency of sibs or selfs. Suspected sibs were also transplanted to the field for further observation and final verification.

Yield and other horticultural characters of entries were measured for comparison.

Results

Comparison of means for various traits showed no significant differences among the three seed types(Table 14). Although the reciprocal cross showed a 1% sibbing rate, this was negligible in practical terms. The strong self-incompatibility of the female inbred, E7, was apparent again from the zero sibbing rate in the direct cross seeds,thus, confirming previous observations. The self-incompatibility of the male line, B18, appeared to be adequate.

Conclusion

Results indicate that seed blending is a real possibility on ASVEG 1. The blended seeds did not differ from either the direct and reciprocal cross in all measured traits. The possibility of seed blending opens up an avenue for a more economical seed production of this hybrid.

Table 14. Yield and other horticultural characters of ASVEG 1 derived from direct and reciprocal crosses and from a 1:1 seed blend of both crosses (AVRDC 1984).

Type of Seed	Sibbing Rate (%)	Yield (t/ha)	DM[z]	Head Weight (g)	Growth (g)	HER[y] (%)	HR[x] (%)	HDR[w] (%)	Soft Rot (%)
Direct	0	14.9	35	468	938	1.0	98	100	3
Reciprocal	1.2	14.7	35	455	919	1.0	99	100	1
Blended	0	14.4	35	454	946	0.9	97	100	3

[z]DM = days to maturity from transplanting. [y]HER = heading efficiency ratio. [x]HR = harvest rate. [w]HDR = heading rate.

Hakuran Backcross Program

Introduction

The attempt to transfer the resistance to downy mildew (DM) and soft rot of Hakuran to tropical Chinese cabbage continued in 1984. New backcross families derived from selfing or repeated backcrosses of 1983 selections to the recurrent tropical stock were developed in the 1983-84 winter season. Materials from these crosses were the subject of further selections this year.

Materials and Methods

Twenty-six families belonging to generations BC2F3 to BC4F1 were sown on September 18 and transplanted to the DM nursery on October 12. Population sizes per family varied but were generally 150 plants or more. Plots consisted of double-row beds, with rows spaced 50 cm apart and plants within rows, 40 cm apart. Every four rows of the segregating families were followed by a row of the spreader cultivar, Ping-luh, a highly susceptible DM check. The entire experimental area was also enclosed with two external rows of this inoculum source.

The recurrent parent, B129, and the resistant donor, Hakuran (B639), were included for comparison. Selection for the most resistant segregants from the best families was made on November 27. Originally, the screening for DM resistance was to be combined with tests and selection for soft rot resistance. However, the cool temperatures during the head-initiation stage were not ideal for soft rot resistance screening. This phase was,therefore, eliminated in this planting.

Results

Three different backcross generations yielded useful selections as far as DM resistance is concerned (Table 15). Many families were either completely susceptible or not resistant enough to warrant further selection. Selection rate was about 3 to 4%. In general, the family means for DM infection rating or infection percentage were no longer comparable to those of the Hakuran parent, except possibly to the family originating from the BC2F3 generation.

Table 15. Selection for downy mildew resistance among various families in the Hakuran backcross program[z]

Family	Gene	Total	Selection		Infection	
			no.	%	rating	%
(B639/B129)//-1/-6/RP	BC4F1	161	7	4	2.8	12.9
" //-1-2/RP	BC3F1	152	4	3	3.1	14.5
" //-10-3(X)	BC2F3	176	6	3	1.6	3.6
B129(RP)	-	43	-	-	2.1	7.9
B639(SR/DMR donor)	-	43	-	-	0.6	0.8
B14(DMS check/source)	-	2,658	-	-	3.1	14.5

[z]Family means taken from random sample of 20 plants per family.

The relatively low downy mildew rating for the recurrent parent (B129), a highly susceptible cultivar, was more due to environmental rather than genetic factors, as the inoculum spread in the nursery was not too uniform at the outset when the ratings were made by pathologists. At selection time, however, the entire plot was nearly wiped out by downy mildew and only the truly resistant ones remained green.

From the 1984 data, it seems that the levels of downy mildew resistance in the more advanced backcross families were lower than in the earlier generations, such as BC2, although it was still possible to select plants with usable resistance levels. Nevertheless, the resistance in these selections was no longer comparable to the strong resistance of Hakuran.

A further comparison of families from different backcross generations is given in Table 16. It should be noted, however, that filial generation in each backcross generation varies. The average downy mildew infection rating and infection percentage of several families in the BC2F3 generation were much lower than those of the BC3 and BC4 families. The above evidence is very preliminary and does not unequivocally indicate that the downy mildew resistance genes in Hakuran reside in the *oleracea* rather than desirably in the *campestris* genome; if so, resistance will be continually lost as the plants eliminate the extra *oleracea* chromosomes with repeated backcrosses. This possibility exists, however, and would be paramount in further consideration of Hakuran as a useful genetic resource for downy mildew resistance breeding.

Table 16. Comparative downy-mildew infection levels among backcross generations in the Hakuran backcross program[z]

Generation	Number of Families	Infection	
		Rating	%
BC2F3	7	1.9	6
BC3F1	6	3.0	13
BC3F2	5	2.7	11
BC4F1	7	2.8	13

[z]Generation means represented by 20 random plant samples per family.

Conclusion

We continued to backcross, test, and select derivatives from the Hakuran backcross program to improve the downy mildew and soft rot resistance of tropical Chinese cabbage. Preliminary evidence from a comparison of different BC families indicated that more advanced generations tended to have lower levels of DM resistance. This subject needs to be further investigated before Hakuran can be disregarded as a genetic resource in the improvement of tropical Chinese cabbage.

Heat Tolerance of Tropical Inbreds x Hakuran Backcross Derivatives

Introduction

In evaluating the Hakuran backcross derivatives in 1983, some lines in the advanced generations were observed to exhibit sufficient uniformity for heading and a close resemblance to the Chinese cabbage recurrent parent. Two of the selected lines were, therefore, mated with some of the tropical inbreds to initially observe their combining ability.

Materials and Methods

Thirty-three combinations were evaluated against ASVEG 1 in summer 1984. The recurrent parent stock, B129, and the donor parent, Hakuran, were included mainly for

comparison of overall morphology with the hybrids. Entries were sown on July 10 and seedlings were transplanted on July 31 in a randomized complete block experiment with two replications. Individual plots consisted of two rows, 4 m long, in a double-row bed. Rows within the bed were spaced 50 cm apart and plants within the row, 40 cm apart. Yield and other horticultural characters were measured from entries which headed.

Results

The best performing combination yielded 21 t/ha in 45 days after transplanting, had 100% heading and harvest rates, averaged 635 g/head with solidity equal to, if not better than, ASVEG 1, and showed no soft rot infection (Table 17). Its differences with ASVEG 1 were statistically insignificant, except in maturity where the latter proved to be earlier. In comparison with the recurrent parent, B129, the best combinations yielded better, matured earlier, produced significantly heavier heads, and had higher heading and harvest rates. Under the natural soft rot epiphytotics in the field, however, they showed no advantage over B129 which did not show any infection.

Table 17. Yield and other horticultural characters of the best entries from crosses between lines derived from the Hakuran BC program and the tropical inbreds.

Cross No	Yield (t/ha)	DM[z]	Head Weight (g)	Solidity (g/cc)	HR[y] (%)	HDR[x] (%)	Soft Rot (%)
10	21 a	45 c-f	635 ab	.64	100 a	100 a	0
7	20 ab	46 c-e	686 a	.58	94 ab	100 a	5
31	19 ab	46 c-e	578 bc	.60	100 a	100 a	0
ASVEG 1	18 a-e	38 g	553 bc	.61	100 a	100 a	0
B129(RP)	8 k	51 ab	323 i	.64	63 e	70 b	0

[z]DM = days to maturity from transplanting. [y]HR = harvest rate. [x]DR = heading rate.

Conclusion

A number of combinations between lines derived from Hakuran BC and tropical inbreds performed comparably to ASVEG 1 and were superior to the recurrent stock B129 in almost every trait measured, except head solidity and natural soft rot infection level. Heat tolerance among the selected lines from the Hakuran backcross program appears already sufficient, as shown by its high level in the combinations. Selection for lines that show good disease resistance and better horticultural attributes should improve the usability of these combinations.

Cytosterility Backcross Program

Introduction

The program to transfer the cytoplasmic sterility (CMS) from radish and mustard (*B. juncea*) into tropical Chinese cabbage continued. As mentioned in previous reports, this mechanism could be a viable replacement for self-incompatibility. The technique involved is simpler and its sterility is more stable across environments than that of self-incompatibility.

A program using more advanced radish-derived CMS materials with improved nectar glands were restarted. In addition, other CMS sources were explored and one from India which was originally derived from mustard was obtained. These materials have been the subject of our attention in the last two years.

Materials and Methods

A total of 35 B2P/3A families of radish-derived CMS materials were planted. Eleven families of this batch originated from backcrosses to 7251-1, a self-fertile heat-tolerant inbred

with a good combining ability, as recurrent parent. The other 24 families belonged to backcrosses to CT1-27 and CT1-32, both self-fertile selections from an open-pollinated tropical cultivar. Population sizes varied among families depending upon availability of seeds but generally ranged up to 165 plants per family. The recurrent parents were included for comparison and as pollen source for further substitution crosses. Selection for dark green leaf color was practised at seedling stage. All severely chlorotic plants were discarded and only the selected plants were vernalized.

At flowering time, five open flowers per plant were sampled for observation, especially of the nectar gland which has always been a serious limitation in radish-derived CMS materials. Final selection of plants for use in further backcrosses included only those with none or minimal chlorosis (at seedling and mature stages); relative absence of diseases, such as downy mildew and turnip mosaic virus; improved nectar gland; and better pod and seed fertility.

On substitution crosses with mustard as the CMS source, we planted a total of 17 families belonging to BC1 to BC3 generations. Six families had B-18 as the recurrent parent. B-18 is a self-compatible tropical inbred with a good combining ability. The rest were backcrosses to B129, an open-pollinated tropical cultivar. Again, preliminary selection was practised at the seedling stage for relatively normal leaf color, discarding the severely chlorotic plants in the process.

The selected plants were then vernalized along with the recurrent parents and, at flowering time, they were examined for functional nectar gland in a random sample of five open flowers per plant. Other floral attributes were also noted. Generally, pod size and seeds per pod of mustard-derived CMS plants were still very poor. Thus, selection was focused mainly on functional nectary, good flower size, green leaf color (at seedling and mature stages), and relative resistance to diseases. The best selections were further backcrossed to their respective recurrent parents.

Results

Tables 18, 19, and 20 summarize the characteristics of the best selections from the radish CMS backcross program as compared with their respective recurrent parents. It is apparent that dark green plants could be selected, although a few light green plants were still taken. Seed and pod fertility from hand and bee pollinations of some of the selections were already comparable, if not better, than those of the recurrent parents. The limitation of these plants was still, in large part, on the nature of their nectar glands. The best possible nectar gland score for the backcross progenies was "8" out of a perfect score of "12" for the normal plant (such as, the recurrent parent). Nonetheless, the current score of CMS derivatives already represents a great improvement over the previous radish-derived CMS materials.

The data on the best selections from the *B. juncea* CMS backcross program with two recurrent parents are given in Tables 21 and 22. The normal check was a normal segregant (83W53N-1) from a BC family which was initially suspected to have had its fertility restored by restorer genes but have not proven to be so in subsequent tests of selfed progenies. The best selection among backcrosses to B-18 was 83W76-2 with petals nearly the normal size, green seedlings, dark green mature plant color, and nectar secretion in the inner glands (Table 21). In backcrosses to B129 the best selections had petals approximately half that of normal. Similarly, some derivatives with green seedlings/dark green mature plant color were present and nectar secretions on some were consistently observed.

Conclusion

The program to transfer cytoplasmic sterility to tropical Chinese cabbage is making progress in terms of leaf color, functional nectary, and pod/seed fertility. In both the radish- and mustard-derived CMS backcross populations, the size of nectar gland was still below normal. However, nectar secretion had been consistently observed in some selections. Petal size of mustard CMS was still generally small, except in one segregant which had a nearly

normal proportion. Pod and seed fertility of mustard CMS need to be improved. With repeated backcrosses, it is expected that a better opportunity for selecting the desired type for this trait will arise.

Table 18. Seedling characters, nectar gland score, and seed production of selection from radish derived CMS backcross with inbred 7252-1 as recurrent parent[z].

Selection	Leaf Color	Nectar Gland Score	Pod Length		No. Seeds/Pod		Pod Set	
			HP (cm)	BP (cm)	HP	BP	HP (%)	BP (%)
83W39-2	DG	8 –	4	3	21	14	69	89
83W48(RP)	N	12	–	4	–	13	–	67

[z]DG = dark green; N = normal; HP = hand pollination; BP = bee pollination.

Table 19. Seedling characters, nectar gland score, and seed production of selections from radish-derived CMS backcross with OP CT1-32 as the recurrent parent[z]

Selection	Leaf Color	Nectar Gland Score	Pod Length		No. Seeds/Pod		Pod Set	
			HP (cm)	BP (cm)	HP	BP	HP (%)	BP (%)
83W13-3	LG	8 –	3	2	20	7	75	60
83W18-2	LG	8 –	4	3	21	12	63	71
83W18-3	LG	8	3	3	13	10	88	98
83W18-2	LG	8	3	2	11	7	73	71
83W22-1	DG	8 –	3	2	18	9	86	78
83W23-1	LG	8	2	2	12	6	80	76
83W29-6	DG	8 +	4	3	17	12	69	74
83W47(RP)	N	12	–	3	–	14	–	74

[z]LG = light green, DG = dark green, N = normal, HP = hand pollination, BP = bee pollination.

Table 20. Seedling characters, nectar gland score, and seed production of selections from radish-derived CMS backcross with OP CT1-27 as recurrent parent[z]

Selection	Leaf Color	Nectar Gland Score	Pod Length		No. Seeds/Pod		Pod Set	
			HP (cm)	BP (cm)	HP	BP	HP (%)	BP (%)
83W12-1	DG	8 –	2	2	9	5	95	78
83W14-1	DG	8 +	3	3	14	6	79	78
83W17-4	DG	8	4	3	17	8	91	74
83W24-2	DG	8 –	3	3	6	9	82	76
83W26-3	LG	8 –	3	3	14	6	81	77
83W26-4	DG	8 –	3	2	10	7	80	70
83W26-5	DG	6	2	2	6	8	67	82
83W26-6	DG	6	2	2	3	2	70	68
83W46(RP)	N	12	–	3	–	10	–	87

[z]DG = dark green, LG = light green, N = normal, HP = hand pollination, BP = bee pollination.

Table 21. Leaf color and floral characters of the best selections from the *B. juncea* CMS backcross with B-18 as recurrent parents.

Selection	Leaf Color[z]		Anther[y]	Petal size[y]	Nectar/Gland[x] (number/size)		Nectar[w]	
	sdlg	mat			inner	outer	inner	outer
83W73-1	G	DG	V	.2N	–	0-2/vs	+	–
83W74-3	G	DG	V	.2N	2/s	2/s	+	–
83W74-2	G	DG	V	.3N	2/vs	2/vs	+ +	–
83W76-2	G	DG	V	.9N	0-2/s	1-2/s	+	–
83W53(N)-1	G	DG	N	N	2/N	2/N	+ +	–

[z]sdlg = seedling; mat = mature plant; G = green, DG = dark green. [y]N = normal, V = vestigial.
[x]s = small; vs = very small. [w] + = nectar occasionally absent on one or both glands (some flowers).
+ + = nectar consistently present on both inner glands. – = nectar completely absent.

Table 22. Leaf color and floral characters of the best selections from the *B. juncea* CMS backcross with B-129 as recurrent parent.

Selection	Leaf Color[z]		Anter[y]	Petal Size[y]	Nectar Gland[x] (number/size)		Nectar[w]	
	sdlg	mat			inner	outer	inner	outer
83W55-6	G	DG	V	.3N	2/vs	1-2/vs	+	–
83W58-3	G	DG	V	5N	2/s	–	+ +	–
83W58-8	–	LG	V	.5N	1-2/s	0-1/s	+	+
83W60-5	–	LG	V	.5N	2/s	0-1/s	+ +	+
83W61-2	G	DG	V	.1N	2/s	0-2/s	+ +	–
83W53(N)-1	G	DG	N	N	2/N	2/N	+ +	–

[z]sdlg = seedling, mat = mature plant, G = green, LG = light green, DG = dark green. [y]N = normal; V = vestigial. [x]s = small, vs = very small. [w] + = nectar occasionally absent on one or both glands (some flowers). + + = nectar consistently present on both inner glands. – = nectar completely absent.

International Trials

A total of 1,525 seed packets were distributed to 174 cooperators in 68 countries. Most of the requests were for ASVEG 1 and a number of open-pollinated cultivars, especially those already released in some countries or found adaptable in others based on cooperators' reports last year. In 43 special cases, we shipped amounts in large quantities ranging from 10 g to as much as 15 kg per entry.

A number of cooperators filed back reports of their trials. In several cases, reports were simply a general summary without supporting data. These reports were not included in this section unless something significant occurred in the trials.

Indonesia

Mr. Simon Field of the Australian Livestock Development Project at Kupang, Indonesia reported the excellent performance of a number of AVRDC hybrids and open-pollinated cultivars in a preliminary trial. Elevation of the trial site was 60 m above sea level. Table 23 shows the promising entries and their characteristics in comparison to B189 (check). The best entries yielded 36 to 38 t/ha in 61 to 65 days, averaged more than 1 kg per head, had no soft rot infection, and showed heading and harvest rates close to, if not equal, to 100%. The differences with the check cultivar were not significant, however, partly because of the relatively high coefficient of variation as in yield.

The Taiwan Agricultural Technical Mission at Central Java tested two of AVRDC's hybrids against two commercial hybrids at two locations. One was at Pakem (elevation, 400 m) and the other was at Ngipiksari (elevation, 850 m). No statistical basis for comparison could be made, but the AVRDC entries yielded at least 40 t/ha in 57 days and averaged at least 1 kg per head (Table 24). They were clearly outyielded by Ping-luh, however, in about the same duration. At the higher elevation of Ngipiksari, ASVEG 1 outyielded Ping-luh. Its reported yield was 56 t/ha in 64 days with a mean head weight of 1.6 kg compared with a yield of 49 t/ha in the same duration and 1.4 kg average head weight for Ping-luh.

The Central Research Institute for Horticulture at Bogor announced the official release of two of AVRDC's heat-tolerant open-pollinated cultivars selected from several entries after several years of tests at different locations. The two varieties, 77M(3)-40 and 77M(3)-26, given the local names "Talaud" and "Sanguihe", respectively, were noted by the research team led by Dr. Hendro Soenarjono to have high yield potential (average of 30 t/ha but with maximum attainable yield of 70 t/ha under more favorable conditions), resistance to soft rot and *Alternaria* (moderate level), but susceptibility to clubroot. In their report, the team cited the adaptability of both cultivars for lowland and highland commercial production.

Table 23. Best performing AVRDC entries in a trial conducted at N.T.T., Kupang, Indonesia.

Entry	Marketable Yield (t/ha)	Days to Maturity	Head Weight (g)	Harvest Rate (%)	Heading Rate (%)	Soft Rot (%)
Hybrid 59	38	61	1149	99	100	0
Hybrid 58	37	62	1121	99	100	0
77M(2/3)-41	36	61	1085	100	100	0
77M(2/3)-43	36	65	1072	96	99	0
B189 (Check)	26	63	822	83	83	14
CV(%)	27	6	20	16	10	–

Table 24. Performance of AVRDC entries and commercial hybrids in a preliminary trial at two locations in Central Java, Indonesia[z].

Entry	Pakem (400 m)[y]			Ngipiksari(850 m)[y]		
	Yield (t/ha)	Days to Maturity	Head Wt (kg)	Yield (t/ha)	Days to Maturity	Head Wt (kg)
Hybrid 58	42	57	1.2	–	–	
ASVEG 1	40	57	1.1	56	64	1.6
Yuan Pao	40	57	1.1	–	–	
Ping Luh	51	57	1.4	49	64	1.4

[z]No statistical analysis provided on summarized results. [y]Elevation from sea level.

Philippines

The Institute of Small Farms and Industries of the Ateneo de Davao University carried out a trial at Upper Rapnaga area (elevation, 16 m) from June to November 1983. The Director of the Institute, Mr. Ronald Vidal, highly recommended the use of Hybrid 58 and B189 in the area. Hybrid 58 clearly outyielded B189 in about the same growth duration of 55 days from transplanting (Table 25). Both averaged about 1.5 kg head weight and 100% heading rate. Harvest rate in B189 was lower than in Hybrid 58 but the difference was insignificant. These two entries did not suffer any soft rot damage although most other entries had substantial incidence. At present, the Institute requires more seeds for further tests and dissemination.

In another trial at Leyte province, researchers from the Visayas State College of Agriculture at Baybay found that 77M(3)-40 was the most vigorous, the least susceptible to soft rot, and produced the biggest head and highest yield of 27 t/ha in the same growth duration as the other varieties in a trial of 10 AVRDC entries (Table 26).

Table 25. Best performing AVRDC entries in a trial conducted at the Upper Rapnaga, Davao City, Philippines.

Entry	Marketable Yield (t/ha)	Days to Maturity	Head Weight (g)	Harvest Rate (%)	Heading Rate (%)	Soft Rot Rot (%)
Hybrid 58	47a	55	1525	94	100	0
B189	37b	56	1432	78	100	0
CV(%)	36	3	24	25	10	49

Table 26. Best performing AVRDC entry in a trial at VISCA, Baybay, Leyte, Philippines.

Entry	Yield (t/ha)	Maturity[z]	Soft Rot[y]
77M(3)-40	27 a	65	1 c
B189 (check)	18 b	62	4 b

[z]Days from sowing to harvest [y]Rated from 1 = least infection to 5 = most susceptible.

Brunei

Dr. Ramon Santiago of the Sinaut Agricultural Research and Training Center tested seven AVRDC entries during the dry and wet seasons of 1983-84. Based on the initial results, two entries, 77M(3)-35 and 77M(2/3)-41, had commercial potential. Yields of the two entries were comparable during the wet season and tended to be higher than in the wet season (Table 27). B189, the check entry, however, yielded very low in the same duration during the dry season. Generally, soft rot was the biggest problem. The two entries, 77M(3)-35 and 77M(2/3)-41, had relatively high incidence but were considered to be the most "tolerant" in both trials.

United States and Australia

Reports filed by cooperators from the more temperate regions also indicated a surprisingly acceptable performance of the AVRDC cultivars bred especially for the tropics. However, the heading ability of the tropical types depended upon the planting season. In a trial conducted by Harris Seed Company at Rochester, New York, AVRDC Hybrid # 58 and # 62 both bolted before heads could form. In the fall trial (transplanted in mid-August), both hybrids matured very early and possessed good quality for the fresh market. However, they had a limited holding capacity in the field, with heads splitting quickly if not harvested soon after they became compact.

Professor S. Honma of Michigan State University at East Lansing reported that as a summer crop, most of the AVRDC-bred tropical Chinese cabbage prematurely bolted with long days and relatively cool nights in that area. Only ASVEG 1 did well and is highly preferred over other Asian cultivars because of the prevailing market demand for smaller heads.

In the semi-arid subtropical area of Northern Australia, AVRDC Hybrid # 62 (ASVEG 1) performed very well in a trial conducted from June to August 1984 by the Department of Primary Production at Darwin. According to Mr. Kevin Blackburn, the horticulturist at the DPI's Berrimah Research Farm, this variety is "a very good, quick-maturing type with light green, attractive, uniform appearance and produces very firm white heads". Both ASVEG 1 and Hybrid 59 averaged more than 100 t/ha in 56 to 58 days, with 100% (or practically so) heading and harvest rates, and mean head weights of about 1 kg (Table 28).

ASVEG 1 is preferred over Hybrid 59 for its market quality. Not included in Table 28 but cited here for comparative purposes are B189 (the heat-tolerant check, which averaged 600 g head weight but with 20% premature bolters) and Yamato-Noen (the heat-sensitive check, which produced some heads that were slightly heavier than that of ASVEG 1—about 30 g more). However, Yamato-Noen had about 30% nonheaders and "bud rot"-infected plants which severely reduced its final per unit area yield.

Table 27. Best performing AVRDC entries in the dry and wet seasons at Sinaut, Brunei[z]

Entry	Yield(t/ha)		Maturity(days)		Head Weight(g)		Soft Rot(%)	
	dry	wet	dry	wet	dry	wet	dry	wet
77M(3)-35	16	22	57	42	633	479	36	23
77M(2/3)-41	–	24	–	42	–	652	–	39
B189 (check)	5	–	57	–	491	–	69	–

[z]No statistical analyses included with the summarized data

Table 28. Best performing AVRDC entries in a trial conducted at the Berrimah Research Farm, DPP, Darwin, NT Australia.

Entry	Yield (t/ha)	Days to Maturity	Head Weight (g)	Harvest Rate (%)	Heading Rate (%)
ASVEG 1	118	56	1060	100	100
Hybrid 59	125	58	1150	99	99
CV(%)	16	4	8	15	10

21

Chinese Cabbage Entomology

During 1984 studies were continued on control of cabbage webworm *Hellula undalis* (Lepidoptera: Pyralidae) and diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) which are the most serious pests of Chinese cabbage in the hot humid summer and cool dry winter, respectively, in Taiwan and practically throughout the year in tropical and subtropical regions of Asia.

Screening Chinese Cabbage Germplasm for Resistance to Cabbage Webworm

Introduction

During 1978 and 1980 available Chinese cabbage germplasm was screened for resistance to cabbage webworm. However, we did not find any resistant Chinese cabbage accession. During the last three years additional germplasm was received. This germplasm, along with accessions not included in past tests because of inadequate seed supply, was screened for resistance to cabbage webworm in summer 1984.

Materials and Methods

A piece of land away from areas of frequent insecticide use was rototilled, applied with basal fertilizer, and worked into 1.5 m wide raised beds. These beds were further divided into 10 m long plots. On each plot, seeds of each accession were sown in two rows, with a distance of 40 cm between rows and 25 cm between hills in each row. Each accession was planted in three randomly selected plots. Two weeks after germination each plot was thinned to two plants per hill. At this time, several cabbage webworm pupae were placed at regular distances all over the field to augment ambient cabbage webworm population and to increase the chances of infestation.

Six weeks after sowing, each plant in each plot was observed and the number of healthy and webworm-damaged cabbage plants were recorded. The mean and standard deviation of the percentage of plant damage of each accession were calculated. This procedure allowed us to classify the accessions according to the following categories: highly resistant (HR), moderately resistant (MR), low resistance (LR), susceptible (S), and highly susceptible (HS).

Results

All accessions were damaged by cabbage webworm (Table 1). The damage percentage varied from 12.26 to 66.60. The 19 least damaged MR accessions will be screened again next year for resistance to cabbage webworm.

Conclusion

In a preliminary test, 19 out of 133 accessions screened for resistance to cabbage webworm were relatively less damaged than the others.

Table 1. Performance of Chinese cabbage accessions for resistance to cabbage webworm.[z]

Resistance Category	Percentage of Plant Damage Range	No. of Accessions
HR	less than 9.07	0
MR	9.08 to 21.40	19
LR	21.41 to 33.73	53
S	33.74 to 58.40	55
HS	greater than 58.41	6
	total	133

[z]Sowing date: July 31, 1984; observation date: Sept. 12, 1984. Mean damage percentage: 33.73; standard deviation: ± 12.33.

Insecticide Screening for the Control of Cabbage Webworm

Introduction

Cabbage webworm infests Chinese cabbage and other cruciferous crops in the seedling stage mainly during the hot and humid summer. The adult female lays eggs on the leaves, and the newly hatched larva moves from its initial feeding site on leaves to the growing point where it continues to feed by boring a hole and remaining concealed. A slight feeding damage to the growing point causes seedling death or deformity in head formation at a later stage.

Since other control methods have not yet been developed for this pest, farmers rely on insecticide application. There is an ongoing insecticide screening program to combat this and other pests of AVRDC crops. In 1984 three new pest control agents were obtained: Bag-a-bug (*Bacillus thuringiensis*), Baythroid, and diflubenzuron for testing. These pest control agents have different modes of action. They were, therefore, included with other chemicals which have shown superior control of this pest in past tests.

Materials and Methods

The procedures were identical to the ones described in our publication "Vegetable Pest Control: Insecticide Evaluation Tests". In brief, it included nine insecticide treatments and one untreated check. Each insecticide was sprayed once a week to designated Chinese cabbage plots of 4.5 × 3.3 m size starting within a week of transplanting. Each treatment had four replicates arranged in a randomized complete block design. Suitable pre-and post-planting cultural practices were adapted to provide high yield.

For efficacy evaluation, the larvae of cabbage webworm were observed on randomly selected 10 plants per plot. Also recorded was the number of webworm-damaged plants as, at times, the larvae after feeding, left the plant for pupation in the soil. Insect count and plant damage percentage were statistically analyzed by Duncan's Multiple Range Test.

Results

The results of insecticide evaluation are summarized in Table 2. Profenofos, EPN, and parathion gave significant cabbage webworm control over untreated check plots in both observations. These insecticides also gave greater marketable yields than the control and certain other chemicals. Baythroid, diflubenzoran, and both formulation of *Bacillus thuringiensis* (Bactoseine and Bag-a-Bug) were relatively less effective. According to the summer market price for Chinese cabbage (NT$6.00/kg), the return on increased production was worth NT$18,030, NT$15,288, and NT$17,000 for profenofos, EPN, and parathion, respectively. The costs of these chemicals for four applications per hectare were NT$2,850, NT$612, and NT$400.

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

Insecticides	Rate (kg a.i./ha)	No.of Larvae /10 Plants		Percentage of Damaged Plants/Plot		Yield (t/ha)
		84/7/9	84/7/16	84/7/9	84/7/16	
Profenofos 50EC	0.5	1.00c	0.50d	17.72	19.28	20.28a
Bactospeine 100%	0.5[y]	6.00a	7.00a	29.68	29.72	13.51b
Baythroid 50EC	0.05	7.50a	4.75ab	33.33	23.44	14.72b
Bag-A-Bug 100%	0.5[y]	2.75bc	3.75bc	28.12	25.00	17.05ab
EPN 45EC	0.5	0.00c	0.25d	16.67	25.55	19.45a
Triazophos 40EC	0.5	2.00bc	0.25d	19.27	27.09	15.78ab
Methomyl 90WP	0.5	4.50ab	4.50ab	19.79	20.89	18.02ab
Difluenzuron 25WP	0.075	1.00c	1.25cd	22.84	19.81	16.85ab
Parathion 47EC	0.5	0.25c	0.75d	11.99	26.65	19.70a
Control		6.00a	4.75ab	22.92	30.20	16.80ab

[z]Cultivar: ASVEG #1. Transplanting date: June 29, 1984. Insecticides applied: July 5, July 11, July 18, July 25, 1984. Sampling dates: July 9, July 16, 1984. Harvest date: Aug 6, 1984. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test. Plot size: 15 sq. m. [y]Actual product.

Conclusion

Profenofos, EPN, and parathion gave better control of cabbage webworm than several other chemicals. The application of these chemicals was also cost effective.

Influence of Intercropping on Diamondback Moth Infestation of Common Cabbage

Introduction

Diamondback moth is the most destructive pest of most cruciferous crops in tropical and subtropical Asia. As a result of frequent insecticide use, this pest has become resistant to most chemicals that are available in the market. New insecticides are not developed fast enough to replace the old ones. Insect resistance, insecticide cost, and health hazards make it necessary to develop alternatives which can be integrated with other methods, including insecticide use to minimize insect damage. In 1984 we conducted two experiments, one on intercropping and the other on irrigation to control this pest. The results of the intercropping experiment are summarized here.

Materials and Methods

A 0.6 ha piece of land was rototilled, applied with basal fertilizers, and worked into 1.5 m wide beds which were further divided into 10 m long plots. There were 309 plots representing 103 treatments and three replicates.

Seeds of 99 different crops were obtained from Taiwan, India, USA, and Thailand. The seeds of each crop were planted in two lines, 40 cm apart on each plot. Six plots were left as nonintercropped checks. The planting of the intercrop was arranged in a randomized complete block design.

One month after the sowing of intercrops, four-week-old common cabbage seedlings were transplanted in a single row at the center along the length of each plot. The crop was raised according to customary cultural practices, except that no insecticide was applied.

At 40, 60, and 80 days after transplanting, diamondback moth infestation was observed on the common cabbage. In each plot, 10 plants were selected at random, and the population of larvae (2nd instar or older) and pupae on each plant were recorded.

Since aphids also infested common cabbage, their number was also observed on the plants selected for diamondback moth infestation. In the first evaluation 40 days after transplanting, the number of aphids on each plant were recorded and the plants were grouped as having 0 to 10, 11 to 100, 101 to 1000, and 1000+ aphids/plant. At 60 days after transplanting, aphid population was higher, so the plants were grouped as having less than 1000, 1001 to 5000, 5001 to 10,000, and more than 10,000 aphids/plant.

The aphid count was converted to weighted averages by multiplying the number of plants in each category by a factor of 1 (0 to 10 aphids in 1st and less than 1,000 aphids in 2nd observation), 2 (11 to 100 aphids in the 1st and 1,000 to 5,000 aphids in the 2nd observation, 3 (101 to 1000 aphids in the 1st and 5,001 to 10,000 aphids in the 2nd observation), 4 (more than 1,000 aphids in the first and more than 10,000 aphids in the 2nd observation).

The combined damage of diamondback moth and aphids was evaluated at 80 days after cabbage transplanting. Twenty-two randomly selected plants were evaluated for insect damage according to five categories: 1 (little damage with a large head), 3 (little damage with a medium head), 5 (moderate damage with a medium head), 7 (serious damage with a small head) and 9 (serious damage and no head).

The diamondback moth count, the weighted averages of aphid count, and damage rating observations were statistically analyzed by Duncan's Multiple Range Test.

Results

Among 99 intercrops, only 54 grew successfully; others did not survive or grew very poorly due to cold weather. The influence of intercropping with these 54 crops on insect infestation was evaluated. The crops are as follows: amaranthus (*Amaranthus blitum*), Aztec marigold (*Tagetes erecta*), barley (*Hordeum vulgare*), barnyard millet (*Echinochloa crusgalli*), berseem (*Trifolium alexandrinum*), broccoli (*Brassica oleracea* var. *italica*), brussels sprout (*Brassica oleracea* var. *gemmifera*), buckwheat (*Fagopyrum sagittatum*), carrot (*Daucus carota*), cassava (*Manihot esculenta*), cauliflower (*Brassica oleracea* var. *botrytis*), celery (*Apium graveolens*), common cabbage (*Brassica oleracea* var. *capitata*), chilli pepper (*Capsicum frutescens*), Chinese cabbage (*Brassica campestris* subsp. *pekinensis*), coriander (*Coriandrum sativum*), corn (*Zea mays*), cosmos (*Cosmos sulphureus*), cucumber (*Cucumis sativus*), daisy (*Bellis perennis*), dill (*Anethum graveolens*), eggplant (*Solanum melongena*, four-o'clock (*Mirabilis jalapa*), garlic (*Allium sativum*), hollyhock (*Alcea rosea*), kale (*Brassica oleracea* var. *acephala*), kodo millet (*Paspalum scrobiculatum*), leek (*Allium ampeloprasum*) mesta (*Hibiscus cannabinus*), methi (*Trigonella foenum-graecum*), mustard (*Brassica nigra*), oat (*Avena sativa*), pai tsai (*Brassica campestris* subsp. *chinensis*), parsley (*Petroselinum crispum*), pea (*Pisum sativum*), portulaca (*Portulaca grandiflora*), pumpkin (*Cucumis pepo*), radish (*Raphanus sativus*), rape (*Brassica napus*), ridge gourd (*Ruffa aculanguia*), rutabaga (*Brassica napus* var. *napobrassica*), safflower (*Carthamus tinctorius*), shallot (*Allium ascalonicum*), smooth gourd (*Luffa cylindrica*), sorghum (*Sorghum bicolor*), soybean (*Glycine max*), spinach (*Spinacia oleracea*), sugarcane (*Saccharum officinarum*), sweet pepper (*Capsicum frutescens*), sweet potato (*Ipomoea batatas*), tobacco (*Nicotiana tabacum*), tomato (*Lycopersicon esculentum*), white potato (*Solanum tuberosum*), and wild tomato (*Lycopersicon hirsutum* f. *glabratum*).

Common cabbage planted between barley, dill, garlic, oat, safflower, and tomato had relatively less diamondback moth larvae and pupae, especially during the third observation when insect population was very high (Table 3). It must be emphasized here that due to wide variations among replicates, the results were not satistically significant. Crops like safflower, oat, and barley grew tall and shadowed the cabbage plants, which adversely affected cabbage growth and insect count.

Table 3. Population of diamondback moth on common cabbage intercropped with selected crops.[z]

Intercrop	No. Larvae + Pupae/10 Cabbage Plants (days after transplanting)		
	40	60	80
Barley	39	12	64
Dill	44	25	62
Garlic	42	20	69
Oat	36	12	83
Safflower	19	11	0
Tomato	15	10	166
Control	37	33	330

[z]Cabbage transplanting date: Dec. 12, 1983.

All cruciferous intercrops acted as trap crops. Since they were planted earlier than common cabbage, most of the insects infested them and very few moved on to the common cabbage planted later.

During the first observation at 40 days after transplanting, certain intercrops influenced the aphid population on common cabbage; however, at 60 days after transplanting, when aphid population was very high, none of the crops had any significant influence on aphid infestation of common cabbage.

Conclusion

Common cabbage planted between barley, dill, garlic, oat, safflower, and tomato had relatively less diamondback moth infestation than when common cabbage was grown as a sole crop.

Influence of Tomato Leaf Extract Spray on Diamondback Moth Oviposition

Introduction

Our intercropping experiment and other investigations showed that common cabbage intercropped between tomato reduced diamondback moth infestation of cabbage. So, we decided to pursue this aspect further and study the mechanism involved in this finding. In this first of a series of experiments, we studied the effect of tomato leaf extract on the oviposition of diamondback moth in treated common cabbage and Chinese cabbage plants.

Materials and Methods

With common cabbage—free-choice test. Leaves of both cultivated tomato (*Lycopersicon esculentum*) and wild tomato (*L. hirsutum* f. *glabratum*) were collected from the field where no insecticide was used. Two-hundred-gram leaves were transferred to a Waring blender containing 2 liters of water and were extracted at high blending speed for 3 min. The extract was filtered through a single layer of muslin cloth and the filtrate stored at 5° to 8°C.

Common cabbage (cv. K.Y. Cross) plants were raised for four weeks in small clay pots (one seedling per pot) in the greenhouse. Nine seedlings of uniform size were chosen. Three plants were sprayed with cultivated tomato extract, three with wild tomato extract, and three with water. With a laboratory atomizer, the plants were sprayed until the extract began to run off. The liquid was allowed to evaporate for 5 to 10 min.

A set of three seedlings, each one sprayed with one of the three treatments was transferred to a nylon net cage (45 × 45 × 41 cm). There were three cages each representing one replicate. Thirty newly emerged diamondback moth adults were released inside each cage. Once every other day, the number of eggs on the leaves were recorded and the plants sprayed with their respective treatments and returned to the same cage containing diamondback adults. The recording of oviposition continued until there was an insignificant number of eggs laid on the water sprayed plants.

With common cabbage—no-choice test. In this study two potted common cabbage seedlings were placed in each of the nine nylon net cages. The plants in three cages were sprayed with cultivated tomato leaf extract; in three other cages, with wild tomato leaf extract; and in the remaining three, with water. The spraying procedure was identical with that of the free-choice test. Ten pairs of newly emerged diamondback moth adults were released in each cage. The number of eggs laid was recorded once every other day, and fresh plants sprayed with extracts were placed for further oviposition until an insignificant number of eggs were laid on water-sprayed plants.

With Chinese cabbage. Since in an unrelated experiment we found that With Chinese cabbage the diamondback moth prefers to lay eggs on Chinese cabbage than on common cabbage, in this experiment, we used four-week-old Chinese cabbage (cv. New King) to determine the effect of tomato leaf extract on diamondback moth oviposition. The experimental procedure was identical to that of the free-choice test with common cabbage, except that wild tomato leaf extract was not used; and the treatments were replicated four times, instead of three.

Results

The results of both free-choice and no-choice tests with common cabbage are summarized in Table 4. The number of diamondback moth eggs on both tomato extract treatments was lower than that of the control plants (water spray) when the tomato-extract-treated and control plants were placed together (free-choice test). When the insects were given no choice i.e., they were confined to only one-treatment plants, the eggs laid on extract-treated plants were still numerically less, although not significantly so, than those on water-sprayed plants. In general both wild and cultivated tomato leaf extracts had similar effects on diamondback moth oviposition.

The results of the Chinese cabbage experiment are summarized in Table 5. The diamondback moth laid significantly less eggs on plants treated with tomato leaf extract than on control plants sprayed with only water.

Conclusion

Spraying common cabbage or Chinese cabbage plants with tomato leaf extract reduced the number of eggs laid by the diamondback moth on treated plants.

Table 4. Influence of tomato leaf extract spray on oviposition of diamondback moth.[z]

Spray Treatment	No. Eggs/Plant	
	free-choice test	no-choice test
Wild tomato leaf extract	35b	163
Cultivated tomato leaf extract	60b	239
Water	299a	369

[z]The data are the means of three replicates. The means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test

Table 5. Influence of tomato leaf extract spray on oviposition of diamondback moth on Chinese cabbage.[z]

Spray Treatment	No. Eggs/Plant
Tomato leaf extract	57.5a
Water	160.0b

[z]The data are the means of four replicates. The means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Sprinkler Irrigation for Diamondback Moth Control

Introduction

Nine years of continuous insect-pest monitoring showed that diamondback moth is a serious pest of crucifers only in the dry season which lasts approximately from October to April. Infestation is absent or minimum during the rest of the year. In 1980, when Taiwan experienced a severe drought during summer, considerable diamondback moth infestation was observed. This led us to believe that frequent rains are detrimental to diamondback moth infestation.

In 1983, therefore, we conducted a preliminary experiment in which we used sprinkler and furrow irrigations to study diamondback moth infestation on common cabbage. In the 1983 experiment we obtained a fairly good control of the insect by sprinkler irrigation; however, insect population was relatively low and the yield obtained in control plots was influenced not only by this moth but also by water stress. This year, therefore, we used drip irrigation for the check plots so that all plots receive equal amounts of water. Diamondback moth adults were released in the field to augment ambient insect population.

Materials and Methods

A 0.2 ha piece of land was rototilled, applied with basal fertilizer, and worked into beds 1.5 m wide. These beds were further divided into twelve 9 m × 10 m plots. One-month-old seedlings of common cabbage (cv. K.Y. Cross) were transplanted in two rows on each plot. Each bed, excluding the seedlings, was then covered with rice straw mulch. Starting one week after transplanting, six plots were irrigated by overhead sprinkler irrigation and six, by drip irrigation.

For sprinkler irrigation, a polyvinyl tube bearing a row of holes, was mounted 1 m above the planted area on a central pivotal tube which delivered pressurized water into the horizontal tube. The horizontal pipe was rotated by means of a motor so that water was applied uniformly over each plot. In the drip irrigation, a perforated polyvinyl pipe through which the water flow was placed on the soil surface between two cabbage rows in each bed. The water pressure in both irrigations was the same.

Every other day each plot was irrigated for 5 min at dusk usually starting at 4.30 P.M. Equal water pressure and duration in both irrigations resulted in approximately equal amounts of water delivered to the plots. At 25, 37, and 45 days after transplanting, 20 randomly selected plants in each plot were observed for diamondback moth infestation; and the number of larvae and pupae was recorded. At 25 and 37 days after transplanting, the same 20 plants were observed for aphid (*Myzus persicae* and *Lipaphis erysimi*) infestation; and the number of plants with 100 or more aphids were recorded. At harvest, we recorded the number of marketable cabbage heads and yield per plot. All data were analyzed by Duncan's Multiple Range Test.

Results

The results of diamondback moth and aphid infestation and yields obtained are summarized in Table 6. The number of diamondback moth larvae and pupae were consistently

Table 6. Influence of method of irrigation on diamondback moth and aphid infestation and yield of common cabbage.[z]

Irrigation Method	No.Diamondback Moth Larvae + Pupae/20 Plants			No.Plants/20 with 100 + Aphids/Plant		Marketable Heads (%)	Yield (t/ha)
	Feb. 24	Mar. 6	Mar. 15	Feb. 24	Mar. 6		
Sprinkler	305b	506b	609b	5.0a	1.2b	68b	20.0b
Drip	381a	820a	1061a	8.0a	3.8a	59a	8.3a

[z]Transplanting date: Jan. 30, 1984. Data are means of six replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test

less in the sprinkler than in the drip irrigation plots in each observation. The aphid population was also less in the sprinkler irrigation plots. The number of marketable heads and total yield was significantly greater in the sprinkler than in the drip irrigation plots. The average head of sprinkler-irrigated cabbage weighed 738 g as against only 421 g of the drip-irrigated crop.

Sprinkler irrigation presumably drowns and washes away the diamondback moth larvae feeding on the leaf surface. It probably affects aphids in a similar fashion but to a lesser extent. The falling water drops presumably disturb the adult moths and drive them away, or seriously disturb their overall flying and mating activity, considering that irrigation was done close to dusk when moths are especially active for mating.

This system not only reduced insect infestation but also increased the efficacy of water utilization. Although the initial investment is rather high, the savings in water and insecticide cost would, in the long run more than make up for the initial cost.

Conclusion

The overhead sprinkler irrigation significantly reduced diamondback moth infestation, and increased marketable heads, head weight, and yield of common cabbage.

Oviposition Behavior of Diamondback Moth

Introduction

The diamondback moth infests a wide variety of crucifers. The larvae of the insect feed on the plants and skeletonize the leaves. As a result both quality and quantity of the produce are adversely affected. Since the larvae do not migrate from plant to plant but feed and pupate on the same plant, the selection of the host plant for oviposition by the adult female plays a very important role in host plant infestation. Basic studies on the oviposition of this insect were, therefore, initiated and two initial experiments on its preference between common cabbage and Chinese cabbage were conducted.

Materials and Methods

In the first experiment, common cabbage (K.Y. Cross) and heat-tolerant ASVEG 1 were used; in the second, the same common cabbage cultivar and the winter-type Chinese cabbage New King were employed. The seeds of these cultivars were sown in small clay pots. One week after germination, the plants were thinned to one per pot and maintained in the greenhouse for four weeks. In the first test, two potted plants each of common cabbage and Chinese cabbage (ASVEG 1) were placed in a nylon cage (45 × 45 × 41 cm). Three cages, each representing one replicate, were used.

In the second experiment conducted two weeks later, two potted plants each of common cabbage and Chinese cabbage (cv. New King) were similarly placed in cages. Thirty newly emerged diamondback moth adults were released in each cage. The number of eggs laid by

the diamondback moth were recorded everyday for six days. The plants with eggs were removed daily and were replaced with fresh plants maintained in the greenhouse.

Results

Trichome density and the results of the diamondback moth oviposition on common cabbage and both cultivars of Chinese cabbage are summarized in Table 7. The diamondback moth laid significantly greater number of eggs in both Chinese cabbage cultivars than in common cabbage. Both Chinese cabbage cultivars have trichomes on the leaf surface, whereas common cabbage is essentially glabrous. A study is currently underway to investigate the relationship between trichome density and oviposition of diamondback moth in Chinese cabbage.

Table 7. Trichome density and oviposition of diamondback moth in common cabbage and Chinese cabbage.[z]

Test #	Host Plant	No.Trichomes/25 sq mm		No. of Eggs/ Plant
		upper surface	lower surface	
I	Common cabbage (K.Y. Cross)	0	0	88b
	Chinese cabbage (New King)	1.0	10.7	704a
II	Common cabbage (K.Y. Cross)	0	0	80b
	Chinese cabbage (ASVEG 1)	1.5	3.7	611a

[z]Data are averages of three replicates. Means for number of eggs in each vertical column for each test followed by the same test are not significantly different at the 5% level by Duncan's Multiple Range Test. Chinese cabbage and common cabbage plants had approximately same leaf area.

Screening of Insecticides for the Control of Diamondback Moth and Aphids on Common Cabbage and Chinese Cabbage

Introduction

Insecticides play an important role in the protection of crops, especially vegetable. Since insecticide use increases vegetable production cost, it is essential to know which chemical gives better control at minimum cost. Also, insect pests develop resistance to insecticides, especially if one uses a particular compound frequently. It is, therefore, necessary to screen new compounds or combinations of already existing ones to come up with a suitable chemical before the target insect develops resistance to them. In 1984 we conducted one screening with common cabbage for the control of diamondback moth and one with Chinese cabbage for aphid and diamondback moth.

Materials and Methods

The procedures were identical to the ones described in our publication "Vegetable Pest Control: Insecticide Evaluation Tests". In brief, each test included nine insecticides and one untreated check. The chemicals were selected on the basis of their efficacy on target pests or related species in our previous tests or tests conducted elsewhere. Efforts were made to include chemicals that have modes of action different from the traditional ones. Each chemical was sprayed on an air-pressurized sprayer once a week to designated common cabbage or Chinese cabbage plots 4.5 m × 3 m in size. Each treatment had four replicates. Insecticide spraying was initiated from about 10 days after transplanting and discontinued at 10 days before harvest.

Insecticide efficacy was evaluated at intervals, usually a day before the next insecticide application. At each interval, the number of diamondback moth larvae and pupae found in a randomly selected 10-plant sample in each plot were recorded. For aphids, the number of plants in the same 10-plant sample with 1 to 10, 11 to 100, 101 to 1000 and 1000+ aphids were recorded. At harvest, the marketable yield in each plot was recorded. Insect count and yield data were analyzed by Duncan's Multiple Range Test.

Results

For common cabbage, the results of insecticide screening for diamondback moth control are presented in Table 8. All insecticides reduced diamondback moth infestation and gave increased yield over the control. However, MK936 at 18 g a.i./ha gave the best control of the insect. Profenofos, our standard insecticide, and bendiocarb gave comparable insect control. Yield gains over control were comparable among the three insecticides.

In Chinese cabbage aphids caused much greater damage (and at times plant mortality) than diamondback moth during the cool dry season (Table 9). Because of aphid damage, the diamondback moth infestation was erratic. In this particular test two chemicals, pirimicarb and profenofos, gave better control and better yield. Other chemicals did not control aphids, hence the yields obtained in these chemical-sprayed plots were low. As a results of their failure in aphid control, their efficacy against diamondback moth was poor although some of them (e.g., MK936) worked well against diamondback moth in common cabbage in another test.

Conclusion

MK936, bendiocarb, and profenofos give good control of diamondback moth on common cabbage. Profenofos and pirimicarb gave better control of aphids on Chinese cabbage.

Table 8. Evaluation of insecticides for the control of diamondback moth on common cabbage.[z]

Insecticide	Rate (kg a.i./ha)	No. of Diamondback Moth (larvae + pupae/10 plants)				Yield (t/ha)
		Feb. 22	March 5	March 14	March 21	
1 MK936 1.8EC	0.0045	19.7cd	59.5cde	48.0de	96.7de	81.7ab
2 MK936 1.8EC	0.009	9.2cd	34.2def	24.2de	49.0de	88.0a
3 MK936 1.8EC	0.018	1.0d	7.0f	4.5e	11.5e	85.7a
4 PAY-OFF 31.6EC	0.05	30.2bcd	66.0cd	92.0c	237.2bc	75.3ab
5 PAY-OFF 5WP	0.05	42.2bc	85.5c	179.2b	316.7b	72.4ab
6 Bendiocarb 40WP	0.5	10.0cd	22.5ef	22.5de	78.0de	86.0a
7 Bendiocarb 40WP	0.25	22.5cd	49.2cde	63.0cd	141.0cd	77.9ab
8 Bactospeine	0.5	62.5b	129.0b	157.0b	299.7b	66.5b
9 Selecron 50EC	0.5	14.5cd	30.0def	30.5de	99.5de	85.6a
10 Control		139.0a	208.3a	374.5a	529.0a	44.5c

[z]Cultivar: K-Y Cross. Transplanting date: Jan. 9, 1984. Plot size: 15 sq m. Insecticides applied: Jan. 23, Jan. 30, Feb. 6, Feb. 13, Feb. 27, March 5, March 12, March 19, March 26, 1984. Harvest date: April 2, 1984. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 9. Evaluation of insecticides for the control of diamondback moth and aphids on Chinese cabbage.[z]

Insecticide	Rate (kg a.i./ha)	No.Diamondback Moth (larvae + pupae /10 plants)		No. of Plants/10 with Approximate Number of Aphids/Plant			Yield (t/ha)
		March 12	April 12	10-100	101-1000	1000 +	
MK936 1.8EC	0.0045	3.25b	57.8ab	0.25a	1.25b	8.50a	25.9c
MK936 1.8EC	0.009	8.25ab	34.8ab	0.00a	0.50b	9.50a	33.6b
MK936 1.8EC	0.018	3.00b	40.8ab	0.00a	0.50b	9.50a	24.6c
Dimilin 25WP + Phenthoate 50EC	0.25 + 0.50	7.50ab	57.3ab	0.00a	0.00b	10.00a	23.7c
Dimilin 25WP	0.25	13.75a	57.8ab	0.00a	0.25b	9.75a	24.9c
Phenthoate 50EC	0.50	8.25ab	83.8a	0.00a	0.50b	9.50a	20.0c
Dimilin 25WP + Totalwett	0.25 + 1.00	14.00a	41.5ab	0.00a	0.00b	10.00a	22.6c
Pirimicarb	0.25	13.00a	27.0b	0.75a	6.50a	2.75b	38.5b
Selecron	0.50	5.50b	15.0b	0.75a	5.50a	3.75b	45.7a
Control		13.50a	29.8b	0.00a	0.00b	10.00a	20.1c

[z]Cultivar: New King. Transplanting date: Feb. 21, 1984. Plot size: 15 sq m. Insecticide applied: March 1, March 7, March 14, March 21, March 28, and April 3, 1984. Observation date for aphids: April 12, 1984. Harvest date: April 13, 1984. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Chinese Cabbage Pathology

In-Vitro Testing of Chinese Cabbage Hybrids for Downy Mildew Resistance

Introduction

Past studies have documented downy mildew resistance in field situations with the use of both epidemiological data for planting and data on individual infection characters, such as lesion size and number, etc. While this is probably the best method of testing Chinese cabbage for downy mildew resistance, it also has a number of drawbacks. It requires a large planting area and often needs sprinkler irrigation to supply the necessary humidity for disease development. Testing can only proceed in cooler periods (required for the growth of the fungus), but these same cooler seasons will often vernalize the plants and cause them to bolt. This is especially true of AVRDC's heat-tolerant lines. Still, we hoped to verify downy mildew resistance in some of the heat-tolerant hybrids. With this goal in mind, a series of in-vitro experiments were conducted to examine downy mildew resistance in ASVEG 1, and Hybrids 58 and 59.

Materials and Methods

Peronospora prasitica was isolated from the field and maintained in an illuminated 14 C incubator by weekly transfer of sporangial suspensions to detached cotyledons of Chinese cabbage accession B14. Ten- to twelve-day-old cotyledons were used as a substrate for growing the fungus, which sporulated about one week after inoculation. For routine maintenance, sporangial concentrations were in the range of 10^4 to 10^5 sporangia/ml.

Lines were tested by sowing the seeds and removing the cotyledons when the plants were 12 days old. These cotyledons were placed on moist filter paper in 5 cm petri dishes with the abaxial surface of the cotyledon up. A total of five dishes were prepared for each cultivar or line in this manner. Cotyledons were inoculated with a suspension of sporangia (3.0×10^4 for the ASVEG 1 experiment and 2.4×10^4 for the Hybrid 58 and 59 test). Starting four or five days after inoculation, all five cotyledons were removed from one dish of each cultivar, placed in 5 ml of water, and then shaken with a Vortex-Genie mixer. The concentration of the resulting spore suspension was determined with a hemacytometer. Data was analyzed with the use of multiple regression and a model sequence to see if slopes of different lines were different. Dependent variables were either spore number or spore number transformed by taking its square root. The independent variable was days after inoculation.

Results

The regression coefficients that resulted from fitting separate lines for each line or variety tested are presented in Table 1. These data are also presented graphically in Figs. 1 and 2. In general, the transformed data fit much better than the raw data. This would be expected,

since spores were being counted to determine the dependent variable, and their distribution would be expected to be Poisson. Various reduced models were used to determine whether or not regression lines were separate, or if the data available could just as well be explained by a single line. The ANOVAs for these model sequences are presented in Tables 2 to 5. Similar results from the ANOVA's were obtained whether raw or transformed data were used.

Table 1. Regression coefficients.

Equation for	Sqrt(spore#)		Spore#	
	intercept	slope	intercept	slope
Hybrid 58	-1.61773	.74301	-19.25	4.85
Hybrid 59	-2.67724	.812992	-19.575	4.375
E7	-2.0879	.584204	- 9.475	2.075
E9	-2.98203	.701829	-12.675	2.525
N4	- .467111	.724686	-19.375	6.075
B14	-2.79101	1.07034	-35.45	8.7
8362	-3.62459	.954349	-17.3	3.975
8362R	-4.47494	1.13715	-24.6	5.525
E7	-2.40475	.773972	-12.85	3.275
B18	-3.72018	.964236	-20.1	4.475
B14	-3.23336	1.09836	-26.3	6.725

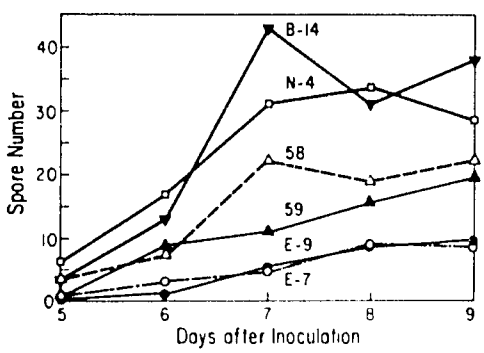


Fig. 1 Increase in spore production over time of Hybrids 58, 59, and parents.

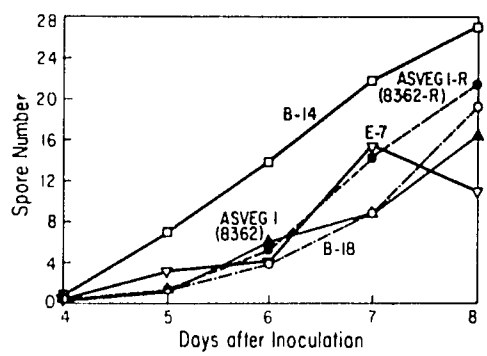


Fig. 2 Increase in spore production over time of ASVEG 1 and parents.

Table 2. ANOVA comparing Hybrids 58, 59, parents, and B14[z].

Source	DF	SS	MS	F
Intercept	1	23744.5	23744.5	203.44
Day	1	5453.07	5453.07	46.72
Residual	118	13772.4	116.7153	
Additional SS for susceptible B14	2	3852.54	1926.27	22.53
Residual	116	9919.8	85.51552	
Additional SS for F1's and parents	2	131.76	65.88	.77
Residual	114	9788.04	85.86	
Additional SS for separating E7/E9 from N4	2	4760.23	2380.115	53.02
Residual	112	5027.81	44.89116	
Additional SS for separating 58 from 59, and E7 from E9	4	141.8	35.45	.78
Residual	108	4886	45.24074	

[z]Dependent variable is spore number.

In the model sequence with Hybrids 58 and 59, all lines (as a group) were different from the susceptible check, B14, indicating detectable resistance in these lines to downy mildew. The comparison of the hybrids (58 and 59 as a group) with their parents (E7, E9, and N4 as a group) showed that there was no difference between these two groups. This can be interpreted that the downy mildew resistance is an additive effect. The two inbreds (E7 and E9), as a group, were more resistant than N4, since the rate of spore production was much less. The final model in the sequence examined whether the rate of spore production of Hybrid 58 was different from that of Hybrid 59 and whether that of E7 was different than that of E9. This was not significant.

The model sequence for ASVEG 1 yielded different results. The rate of spore production for all lines of interest was less than that of B14. In the remaining comparisons, none of the rates were different, except for ASVEG 1 compared to its reciprocal cross. In this case, there was a difference if raw data were used; however, this was not reflected in the transformed data.

Table 3. ANOVA comparing Hybrids 58 and 59, parents, and B14.[z]

Source	DF	SS	MS	F
Intercept	1	1311.61	1311.61	664.12
Day	1	143.34	143.34	72.58
Residual	118	233.046	1.974966	
Additional SS for susceptible B14	2	50.972	25.486	16.24
Residual	116	182.074	1.569603	
Additional SS for F1's and parents	2	6.072	3.036	1.96
Residual	114	176.602	1.549140	
Additional SS for separating E7/E9 from N4	2	93.0742	46.5371	62.40
Residual	112	83.5278	.7457839	
Additional SS for separating 58 from 59, and E7 from E9	4	3.6696	.9174	1.24
Residual	108	79.8592	.7394278	

[z]Dependent variable is sqrt sport number

Table 4. ANOVA comparing ASVEG 1, parents, and B14.[z]

Source	DF	SS	MS	F
Intercept	1	7293.16	7293.16	268.85
Day	1	4598.4	4598.4	169.51
/Residual	98	2658.44	27.12694	
Additional SS for susceptible B14	2	945.25	472.625	26.48
Residual	96	1713.19	17.84573	
Additional SS for F1's and parents	2	42.64	21.32	1.20
Residual	94	1670.55	17.77181	
Additional SS for separating B18 from E7	2	28.82	14.41	.81
Residual	92	1641.73	17.84489	
Additional SS for separating ASVEG1 from the reciprocal cross	2	88.05	44.025	2.55
Residual	90	1553.68	17.26311	

[z]Dependent variable is spore number.

Table 5. ANOVA comparing ASVEG 1, parents, and B14.[z]

Source	DF	SS	MS	F
Intercept	1	586.669	586.669	787.11
Day	1	194.287	194.287	260.67
Residual	98	73.0439	.7453459	
Additional SS for susceptible B14	2	22.4772	11.2386	21.34
Residual	96	50.5667	.5267365	
Additional SS for F1's and parents	2	1.3535	.67675	1.29
Residual	94	49.2132	.5235447	
Additional SS for separating B18 from E7	2	1.0262	.5131	.98
Residual	92	48.187	.5237717	
Additional SS for separating ASVEG1 from the reciprocal cross	2	1.2759	.63795	1.22
Residual	90	46.9111	.5212344	

[z]Dependent variable is sqrt spore number

Conclusion

This method allows the quantification of downy mildew resistance without elaborate field tests and the corresponding problems. This type of resistance still needs to be correlated with actual performance in the field, however. Still, in early stages, even partial downy mildew resistance in Chinese cabbage may be measured under laboratory conditions.

Evauluation of the Inoculation Technique for Chinese Cabbage Soft Rot

Introduction

This experiment is a virtual duplicate of one done last year which investigated the different types of Chinese cabbage inoculation for soft rot resistance. We are trying this since the currently used method (injecting a suspension of bacteria into the outer leaves) cannot be used to examine certain aspects of soft rot development.

Materials and Methods

A 2 by 4 factorial design was used with four replicates in a randomized complete block design. One factor consisted of breaking two leaves per plant, and the other one used one of four different inoculation methods (Table 6). These different inoculation methods were 1) no inoculation, 2) injection inoculation (1 ml of .3 OD suspension per plant injected at two sites), 3) spraying with overhead spray nozzles with the use of the same suspension to run off, and 4) spraying as in method 3 but with drop nozzles. Seed was sown on July 10 and the resulting plants transplanted to the field on August 1. Plants were inoculated on August 31 and diseased plants counted on September 6.

Analysis of both incidence and transformed incidence was performed with an analysis of variance (Tables 7 and 8). Contrasts of treatment means were performed to examine the main effects and interactions (Table 9).

Table 6. Treatments and means (raw and adjusted) of factorial experiment investigating the mode of inoculation.

Treatment	Mean Rot Incidence	
	Raw	Transformed
1. Unbroken leaves, no inoculation	.00	.00
2. Broken leaves, no inoculation	.02	.06
3. Unbroken leaves, injection inoculation	.88	1.28
4. Broken leaves, injection inoculation	.92	1.30
5. Unbroken leaves, overhead spray inoculation	.06	.18
6. Broken leaves, overhead spray inoculation	.88	1.28
7. Unbroken leaves, drop nozzle spray inoculation	.02	.12
8. Broken leaves, drop nozzle spray inoculation	.47	.76

Table 7. ANOVA from the soft rot inoculation factorial experiment—raw data.

Source	DF	SS	MS	F
Treatment	7	5.19726	0.74247	95.66
Block	3	0.00984	0.00328	0.42
Error	21	0.16299	0.00776	

Table 8. ANOVA from the soft rot inoculation factorial experiment.[z]

Source	DF	SS	MS	F
Treatment	7	9.8615	1.41374	47.44
Block	3	0.02463	0.00821	0.28
Error	21	0.62582	0.02980	

[z]Data transformed with the use of the arc-sine square root to stabilize variance.

Table 9. Values of contrasts (and their t-values) from the soft rot inoculation factorial experiment (raw and transformed data).

Contrast Name	Raw Data		Transformed Data	
	value	't'	value	't'
Main effects				
Breaking	-1.32	-10.59	-1.82	-7.43
Inoculation	3.20	14.83	4.72	11.16
Method	-2.16	-14.12	-2.80	-9.37
Nozzle	0.46	5.17	0.59	3.40
Interaction contrasts				
Breaking by inoculation	-1.23	-5.58	-1.56	-3.68
Breaking by method	-1.18	-7.70	-1.70	-5.68
Breaking by nozzle	-0.37	-4.25	-0.46	-2.65

Results

Both transformed and untransformed data gave similar results. This year there was an interaction between breaking the leaves and inoculation, breaking the leaves and the mode of inoculation, and breaking the leaves and the type of nozzle used to spray the plants. An examination of the means from the ANOVA showed that this is due to varying increases in rot because of leaf breaking within the different inoculation techniques. In uninoculated treatments, the effect of leaf-breaking was very small, as would be expected. In injection inoculation, the effect of leaf-breaking was also quite minimal. In the spray treatments,

however, the effect of leaf-breaking was quite large, with a very large increase in the overhead spray treatment, and less increase in the drop-nozzle spray treatment.

Conclusion

Since injection inoculation also damaged the plant at the same time, and bypassed the need to wound the plants for infection to take place, it was not unreasonable for leaf-breaking to have little effect with this mode of inoculation. Overhead spray inoculation was more effective than the drop nozzle spray. The exact reason for this was not known, although the inoculum would run down the leaves and collect by the petiole scars-the exact place where infection would take place, and presumably, the same area where wounds caused by leaf-breaking would be.

Effect of Plant Density on Soft Rot of Chinese Cabbage

Introduction

Soft rot, caused by *Erwinia carotovora*, is an important disease of Chinese cabbage, and can cause substantial losses in the warm summer months. The bacteria normally enters through wounds in the leaves or stems of the plants. Since closer plant spacing prevents the natural healing of these wounds, this experiment was conducted to see if there was a relationship between plant density and the amount of soft rot that developed.

Materials and Methods

Seeds of Chinese cabbage (variety Fun-lu, B141) were sown on July 10 and the resulting plants transplanted to the field on August 1. Plants were set out in either one, two, or three rows per bed, with spacings of 0.3, 0.4, 0.5, and 0.6 m between plants in each row. This produced plant densities from 1.67 to 2.83 plants/m^2 for the one-row beds, 3.25 to 6.5 plants/m^2 for the two-row beds, and 4.92 to 9.83 plants/m^2 for the three-row beds. These 12 densities were arranged in a randomized complete block design with three replicates. Plants were inoculated on August 31 by spraying them to run off with a suspension of *E. carotovora* subsp. *carotovora*. Rotted plants were counted on September 17, September 24, and October 1. Sprinkler irrigation was applied on September 19.

The resulting data were converted to incidence (rotted plants divided by total number of plants in the plot) and analyzed with the use of regression analysis, with incidence as the dependent and plant density as the independent variable.

Results

No clear relationship between plant density and soft rot incidence was evident from these data. Regression models fitting separate lines to the one, two, or three rows per beds, or to the separate blocks, did not yield satisfactory results either. Data from selected ANOVAs are presented in Tables 10, 11, and 12. Transformation of the incidence data to arc-sin-square root did not improve the fit.

Conclusion

Evidently, factors other than plant density play a major role in determining soft rot incidence. One possibility is that wider spaced plants undergo increases insect feeding, and that this increases the amount of soft rot. Further studies are needed before the relationship between plant density and soft rot can be defined.

Table 10. ANOVA from soft rot density experiment, 48 days after transplanting.

Source of Variation	DF	SS	MS	F
Intercept	1	4 74514	4.74514	197.2542
Blocks	2	1367723	.0683862	2.842793
Density	1	0682012	.0682012	2.835105
Error	32	769791	.0240560	

Table 11. ANOVA from soft rot density experiment, 55 days after transplanting.

Source of Variation	DF	SS	MS	F
Intercept	1	11.1062	11.1062	314.8295
Blocks	2	1020958	.0510479	1.447064
Density	1	.0256711	.0256711	.7277033
Error	32	1 12886	.0352769	

Table 12. ANOVA from soft rot density experiment, 62 days after transplanting.

Source of Variation	DF	SS	MS	F
Intercept	1	14.6867	14.6867	385.2818
Blocks	2	.0515974	.0257987	.6767869
Density	1	.0601105	.0601105	1.576902
Error	32	1 21982	.0381194	

Screening of Germplasm for Resistance to TuMV Strains C4 and C5

Introduction

Preliminary screenings have indicated that resistance to TuMV strains C1, C2, and C3 are commonly found in Chinese cabbage. Resistance to strains C4 and C5, on the other hand, is not often found. For this reason, the screening of Chinese cabbage germplasm is done initially with these two strains.

Materials and Methods

Thirty-five *Brassica* sp. accessions (577, 578, 581, 594-599, 601, 604-606, 609-611, 619, 620, 622-625, 627, 629, 641-643, 648, 651, 653, 656, 659, 693, 728, 729) were screened for resistance to TuMV-C5 and 13 new accessions (784-787, 789, 790, 792, 793, 796, 798, 806, 819, 820) for resistance to TuMV-C4.

Inocula were prepared by grinding one part fresh *B. juncea* leaves, infected with either TuMV-C4 or TuMV-C5, in five parts phosphate buffer, containing 0.1% DIECA. Symptoms were recorded 14 days after inoculation. Symptomless plants and those with very mild symptoms were checked by ELISA.

Results

None of the tested accessions were resistant to strain C-5. Two accessions however, B648 and 653, included 75% and 66% of noninfectd plants. Of the new accessions only B819 and B820 showed resistance to C4.

Conclusion

Resistance to TuMV strain C5 is difficult to find in Chinese cabbage.

Chinese Cabbage Physiology

Water Use of Heat-Tolerant and Heat-Sensitive Chinese Cabbage Plants

Introduction

High temperature is detrimental to the head formation of Chinese cabbage. Circumstantial evidence, however, suggests that the heat tolerance of Chinese cabbage depends on a plentiful supply of water throughout plant growth and the ability of the plant to uptake and preserve water. However, there is no evidence concerning the actual amount of water used by Chinese cabbage with different levels of heat tolerance. So, the purpose of this study was to determine how much water is used by Chinese cabbage under high temperature conditions.

Materials and Methods

Seedlings of B-33 (heat-sensitive, Chang-puh Late) and AVRDC Hybrid No. 62 (heat-tolerant) were first prepared in small plastic pots with sand and soil mixture (1:1). Seedlings at three weeks were later transplanted to wooden boxes (25 × 25 × 30 cm) filled with sand and soil but underlaid with a 23-cm width PVF sheet. PVF sheets served as water carriers and as an extension through the bottom-side slit of wooden boxes to outside water containers. The PVF sheets between boxes and water containers were covered with a dark plastic film to prevent direct evaporation and algal growth.

The completely dried culture medium was first fertilized with 3.2 g of N, 1.8 g of P_2O_5, and 2.6 g of K_2O per box before being poured into wooden boxes at 21 kg/box. The culture medium in each box was first equilibrated with water from the water container through PVF sheets for two weeks before total water uptake was measured. Seedlings were later transplanted. No top irrigation was given throughout the experiment; the PVF sheets served as sole water supplier from the water container. The sheets between box and water container were kept at 20 or 30 cm.

The experiment was conducted in the greenhouse with mean maximum and minimum temperatures of 35/25°C throughout the 45-day growth period. There were three replicates, each with three wooden boxes, for each variety and PVF sheet length. Water taken up by each wooden box through the PVF sheet was measured from the water loss in the water container. To segregate the amount of moisture loss from the soil surface as opposed to that being lost from the plant, three wooden boxes for each PVF sheet length were filled with the soil mixture at the beginning of the experiment, but without the Chinese cabbage plants, and handled similarly as the treatment containers. These were used as controls and placed between the planted boxes to provide comparable shading. Water used by the plants was calculated by the water loss difference between the planted boxes and the average of the controls.

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

Results

Essentially, there was no head formation and head yield for B33 in this experiment. The average head weight of AVRDC Hybrid No. 62 was 500 g. Our results confirm that Hybrid No. 62 is heat-tolerant and B33 is heat-sensitive under our experimental temperature conditions. Furthermore, in terms of total fresh and dry weights, Hybrid No. 62 had better growth, than B33 (Table 1). However, in terms of total water usage by the plant through transpiration and retention, Hybrid No. 62 used much less water than B33 under both PVF sheet-length conditions (Table 2). On the average, at least 550 ml of water per day were required for both entries during 45 days of growing period. However, the actual amount required would depend upon the stage of growth.

Most of the water utilized by the plant was lost through transpiration; only less than 0.1% remained in the plant (Table 2). The calculated water retention in the plant tended to increase in Hybrid No. 62 both on the weight and the percentage bases during the whole growing period for both PVF sheet lengths. The water retained in Hybrid No. 62 may be attributed to leaf thickness as well as head formation. Water consumption for unit dry-matter production was higher in B33 than in Hybrid No. 62.

Conclusion

Heat-tolerant Hybrid No. 62 plants, which produced heads and greater dry weight than heat-sensitive B33 under high temperature conditions, utilized water more efficiently. Heat-tolerant plants used less total water during the growth period. The water consumed to produce a unit of dry matter was more efficient in Hybrid No. 62 than in B33. Our results support the finding that the heat tolerance of Chinese cabbage depends not only on a plentiful supply of water but, more important, on the plant's ability to uptake water and preserve it within the plant.

Table 1. Head yield and plant growth of Chinese cabbage under greenhouse conditions with water supplied through PVF sheets.

	PVF (20 cm)			PVF (30 cm)		
	B-33	No. 62	difference	B-33	No. 62	difference
Head weight (g/plant)	0	595	**[z]	0	530	**
Nonheaded leaf area (dm^2/plant)	83.8	68.2	*	93.6	53.6	*
Total fresh wt (g/plant)	874	1353	**	927	1233	**
Total dry wt (g/plant)	85	108	*	88	103	ns

[z]Significantly different at 5% (*) and 1% (**), according to the F-test

Table 2. Calculated water usage of Chinese cabbage plants under greenhouse conditions with water supply through PVF sheets

	PVF (20 cm)			PVF (30 cm)		
	B-33	No. 62	difference	B-33	No. 62	difference
Estimated total water usage by plant (l/plant)	27.31	23.62	**[z]	30.40	26.89	*
Water retained within plant (ml/plant)	789	1245	**	840	1130	**
Calculated percentage retained in plant	2.89	5.27	**	2.76	4.20	*
Dry matter production efficiency (ml water/g dry wt)	325	218	*	348	266	+

[z]Significantly different at 10% (+), 5% (*), and 1% (**), according to the F-test.

Tomato Breeding

Crosses, Segregating Populations, and New Introductions

The tropical tomato program continued to bring in additional improvements to the tropical lines. In 1984, nearly 100% of the new lines tested carried resistance to tomato mosaic virus (ToMV). Sometime in 1983, the program started incorporating nematode resistance to the outstanding tropical lines through the backcross method. In 1984, this activity continued with more crosses made to develop nematode-resistant tropical lines and, in most cases, combinations were also designed to incorporate the resistance through the backcross technique (Table 1).

Table 1. Total and type of crosses made in 1984 in the tropical tomato program.

Characters under Transfer[1]	Tropical Parent Stocks		No. Crosses
	HT,BW,Tm2a,F	HT,BW,Tm2a	
Mi, Tm2a, large fruit	6	7	15
Mi, firmness, large fruit(FM)	6	7	24
Mi, large fruit(PT)	6	7	12
Mi, large fruit, rel.firmness	5	5	16
Mi, some BWR, medium fruit	3	7	10
BLSR, some BWR, medium fruit	6	7	13
Dark green shoulder	1	—	4
Alcobaca, dgdg	3	—	3
Others	—	—	65
Total			162

[1]Legend: Mi = nematode resistance gene, Tm2a = ToMV resistance, BLSR = bacterial leafspot resistance, dgdg = dark green, HT = heat tolerant, BW = bacterial wilt resistant, FM = fresh market type, PT = processing type, F = firm

Apart from nematode resistance, special interest was also focused on additional characters that the nematode-resistant donors could contribute, such as large fruit size, fruit firmness, and, in a few cases, added resistance to bacterial wilt. Therefore, keen attention was given to the choice of nematode-resistant parents to insure that additional desirable characters were present, since the recurrent tropical parents invariably lacked them.

As part of the routine breeding activities, various segregating families were planted, screened for appropriate traits, and selected or discarded. The families handled ranged from F2/DC2 to DC5 (mainly from SSD) and BC1 to BC3 populations. The latter was made up mostly of crosses that were segregating for nematode resistance. All in all, a total of 1142 segregating families were planted for selection throughout 1984 from which 1427 individual plant and/or line selections were derived for further tests.

The breeding program received a total of 53 new introductions. These are currently being evaluated for horticultural characteristics for proper cataloguing before they are used. In some cases, a number of these new lines are already being used in crosses, especially when their origins are reliable.

Evaluation of New Germplasm for Heat Tolerance

Introduction

The search for useful germplasm that can be utilized in the breeding program continued in 1984. One of the characteristics that have always been evaluated every year for new incoming germplasm is the ability to set fruits under high summer temperatures in Taiwan. Some of the older accessions are sometimes included for further confirmation.

Materials and Methods

A total of 82 accessions were tested for heat tolerance in 1984. Included in this trial are two of the best heat-tolerant accessions and/or breeding lines in the program. In 1984, these checks were CL1131-13-0-6 and BL6807.

Seedlings were sown on June 20 and transplanted on July 16. Each plot consisted of a single 4.8-m-long row, with plants within the row spaced 40 cm apart. Rows were spaced 1.5 m apart. Since this was mainly an observational trial to sift out the promising accessions, the experiment was not replicated. A more extensive test usually follows once the total entries are reduced to manageable numbers.

On September 10, the fruit set among different entries was rated subjectively on a 0-to-5 scale, where 0 = no fruit set and 5 = high fruit set.

Results

Table 2 shows the distribution of fruit set scores among the different accessions and checks. None of the new collections equalled the fruit-setting ability of the check cultivars. However, three lines were rated medium to high set. Although it needs to be confirmed, the Sri Lankan and Panamanian lines may possibly trace their pedigrees from AVRDC's heat-and wilt-resistant breeding lines, since their respective national breeding programs have been actively developing locally adapted lines with parental stocks from AVRDC. The cultivar Saladette has been reported to be heat-tolerant in previous studies done in the United States and Israel. Our results simply confirmed past findings. On the other hand, its level of heat tolerance did not seem comparable to that of tropically bred lines.

Conclusion

Three accessions had moderate to high fruit-setting ability during the 1984 summer season. A more thorough analysis of their heat tolerance will be done next summer. The parentage of the two lines from Panama and Sri Lanka needs to be confirmed from donors to insure that the breeding program is not simply "recycling" the original genetic resources for heat tolerance when these two lines are ready for use in further breeding activities.

Table 2. Distribution of fruit set scores among new introductions evaluated for heat tolerance (AVRDC 1984).

Scale	Fruit Set	Number of Entries
0 - 1	none - very light	67
1 - 2	very light - light	10
2 - 3	light - medium	2
3 - 4	medium - high	3[z]
4 - 5	very high	2[y]
Total		84

[z]Consist of cultivars T97 (from Sri Lanka), 1- 12 (from Panama), and Saladette (from the USA) [y]Consist of check entries BL6807 and CL1131-13-0-6

Diallel Analysis of Heat-Tolerant Parental Stocks

Introduction

The tropical tomato breeding program has identified and used in the past a number of heat-tolerant accessions to develop improved lines for the tropics. Information on the genetic nature and gene action of heat resistance, however, were limited.

Genotypes vary in their ability to transmit desirable characteristics to their offsprings. This information is essential in the proper choice of parents to use in the breeding program. The type of gene action underlying the inheritance of the desired trait also gives an important clue in deciding the breeding methods that would likely be most effective to improve that trait. In order to generate information on these points, a seven-parent diallel experiment was carried out.

Materials and Methods

Griffing's Method 2 diallel mating scheme, which involves the use of all possible crosses without reciprocals and the selfs of all parents, was adopted in this study*. The seven parental stocks used, each with a varying level of heat resistance, were as follows: L3690, L229, L232, L1076, L2991, L125, and L387. Genetically, the group carries a broad range of diversity since some of the stocks, such as L3690 and L1076, are wild or primitive species; but both cross rather easily with the other *L. esculentum* parents. One of the parents, L387, is completely heat sensitive.

Seeds of all the possible F1's, excluding reciprocals, and selfs of the parents were obtained in December 1982. The materials were sown on April 19 and transplanted on May 12, 1983. The experimental design was randomized complete block with two replications. Individual plots consisted of two rows, 4.8 m long each, in a raised bed, 2 m wide, with rows 1 m apart and plants within the row, 40 cm apart.

Data on fruit set per cluster, antheridial cone splitting, stigma exertion, pollen production, pollen viability, and a few others were collected from various entries with the assistance of the plant physiologists. Standard analyses of variance were carried out for the different traits, and only characters which were measured with sufficient accuracy in the experiment were further analyzed using the diallel method.

Results

Only fruit set percentage and antheridial cone splitting gave fairly reliable results with coefficients of variation (CV) of 15 and 12%, respectively. The other traits ranged in CV from 40 to 44%. Pollen viability and pollen production were extremely difficult to assess accurately. Diallel analysis was carried out, therefore, only on fruit set and antheridial cone splitting.

Table 3 shows that both general combining ability (GCA) and specific combining ability (SCA) were important for fruit set and antheridial cone splitting in this experiment, implying that additive and nonadditive types of gene action are operating on these traits.

Among parents, L3690 had the highest GCA effect for fruit set and thus, was able to transmit the highest level of this trait to its progenies in contrast to others (Table 4). However, its variance for specific effects (15.9) was high, indicating that this ability was not uniformly expressed in all crosses, i.e., some of its F1's had high fruit set, while the others were low. L1076 transmitted its fruit-setting ability more consistently to its progenies than the other parents, although the level of GCA effect is not high. As expected, heat-sensitive L387 gave a negative estimate of GCA effect, and therefore, its F1 progenies with the other parents generally had poor fruit set in contrast to the others.

* Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Biol. Sci. 9: 463-493.

The differences among parents in their ability to uniformly transmit high fruit setting trait to progenies are better visualized in the diallel array of specific effects (Table 5). As may be noted, L3690 had four out of its six possible F1's *cum* other parents with relatively high SCA effects (enclosed in parentheses); but two had markedly lower values. In contrast, all crosses of L1076 had lower SCA effects; but the magnitudes were more consistent throughout its array. L387, which had the highest variance for specific effects, had two crosses with high SCA effects; but the others were low and the variation in SCA values was apparent.

Table 6 shows the crosses with high SCA effects and how they compare with the mid-parent (MP) and better parent (BP) means. In all cases, these F1's held an advantage in fruit set over the theoretical MP means and, with the exception of one cross (L229/L387), also over the BP means. In the entire diallel set, there were six crosses within the range of overdominant gene action, while the rest can be classified under dominance/no dominance gene action type (Table 7). The F1's in the diallel array were all statistically equal to their better parents.

The GCA effects for antheridial cone splitting (ACS) among the different parents are shown in Table 8. L3690 imparted the lowest tendency for anthers to split under high temperatures, followed by L2991 and L1076. The rest of the parents had positive GCA effects for ACS, indicating that they transmit mainly the undesirable ACS tendency to their progenies. Among the desirable parents, L1076 had the lowest variance for specific effects, implying once again, that it can transmit the desired trait more uniformly to its progenies than either L3690 or L2991 which had relatively higher variances for specific effects.

Table 3. Tests of significance for general and specific combining abilities on the components of heat tolerance in a seven-parent diallel experiment (AVRDC 1984).

Source of Variation	Fruit Set (%)	Antheridial Cone Splitting
General combining ability (GCA)	**	**
Specific combining ability (SCA)	**	**

** – Highly significant at P = 0.01.

Table 4. GCA effects and variance of specific effects (S^2si) for fruit setting in a seven-parent diallel experiment (AVRDC 1984).

Cultivar	Fruit Set (%)	GCA Effect[z]	Variance (S^2si)
L3690	38.9	5.58	15.9
L229	35.5	2.47	16.6
L232	35.4	-0.19	9.8
L1076	35.0	1.44	0.8
L2991	24.6	-0.04	11.6
L125	16.5	-2.78	16.6
L387	0	-6.48	21.6

[z]General combining ability, positive effects imply transmission to progenies of high fruit-setting rate.

Table 5. Diallel array of SCA effects for fruit setting in a seven-parent diallel experiment.

Parents	L229	L232	L1076	L2991	L125	L387
L3690	2.7	(4.2)	0.4	(3.9)	(4.1)	(6.7)
L229		-3.8	2.8	1.8	1.9	(8.3)
L232			1.0	2.4	-5.6	1.2
L1076				3.8	1.3	1.2
L2991					(6.3)	-1.2
L125						3.5

The diallel array for specific effects of ACS is given in Table 9. It can be noted that, with the exception of its cross with L387, L1076 had mainly negative values. On the other hand, L3690 showed a wider range of variation in specific effects, although the better values (those enclosed in parentheses) were rather high compared to the others.

All crosses with high specific effects had lower ACS tendencies than either BP or MP means (Table 10). Even the cross L2991/L3690 with the lowest SCA effect had slight

Table 6. Specific crosses with best SCA effects and the relationship of their F1 mean fruit-setting rates to mid-parent (MP) and better-parent (BP) means.

Rank	Combination	Specific Effect[z]	Fruit Set(%)		Advantage(%) over	
			F1	MP[y]	BP[x]	MP
1	L229 × L387	8.3	26.3	17.8	−26	48
2	L3690 × L387	6.7	47.8	19.5	23	145
3	L2991 × L125	6.3	44.3	20.6	80	115
4	L3690 × L232	4.2	53.6	37.2	38	44
5	L3690 × L125	4.1	49.5	27.7	27	79
6	L3690 × L2991	3.9	53.5	31.8	37	68
21	(L232 × L125)[w]	−5.6	31.4	26.0	−11	21

[z]Positive effects imply transmission to progenies of high fruit-setting rate. [y]Mid-parent. [x]Better parent. [w]Combination with the lowest SCA effect included only for comparison.

Table 7. Distribution of gene action types for high temperature fruit set in a seven-parent diallel experiment (AVRDC 1984).

Type	Number of Crosses	Advantage (%) over BP
Overdominance	6	38 to 80[z]
Dominance	15	−25 to 37[y]
Total	21	

[z]Mean fruit set of F1's are significantly higher in six crosses compared to better parent (BP). [y]Mean fruit set of F1's are insignificantly different from that of BP.

Table 8. GCA effects and variance of specific effects (S^2si) for antheridial cone splitting (ACS) in a seven-parent diallel experiment (AVRDC 1984).

Cultivar	ACS Rating	GCA Effect[z]	Variance (S^2si)
L125	4.4	0.35	0.24
L232	4.2	0.40	0.34
L387	4.0	0.38	0.10
L229	3.6	0.16	0.18
L1076	3.5	−0.06	0.09
L2991	2.8	−0.33	0.15
L3690	2.1	−0.90	0.47

[z]General combining ability, negative effects imply transmission to progenies of the desirable low ACS trait.

Table 9. Diallel array of SCA effects for antheridial cone splitting in a seven-parent diallel experiment.

Parents	L232	L387	L229	L1076	L2991	L3690
L125	0.29	0.01	(−0.67)	(−0.74)	0.22	(−0.60)
L232		0.16	0.38	−0.10	−0.33	(−1.26)
L387			0.40	0.12	−0.41	(−0.63)
L229				−0.16	(−0.59)	0.19
L1076					−0.37	−0.09
L2991						0.48

advantages over either means. These advantages were insignificant, however, when compared statistically to the BP mean.

Three out of possible 21 crosses in the diallel set had significantly lower ACS tendencies than the better parent and may, therefore, be categorized as overdominant gene action type (Table 11). The rest of the F1 means were insignificantly different from the BP means and could belong to dominance/no-dominance gene action type.

Table 10. Specific crosses with best SCA effects and the relationship of their F1 mean ACS ratings to mid-parent (MP) and better-parent (BP) means.

Rank	Combination	Specific Effect[z]	Mean ACS Rating[y]		Advantage(%)over[x]	
			F1	MP	BP	MP
1	L232 × L3690	- 1.26	1.2	3.2	- 43	- 62
2	L125 × L1076	- 0.74	2.5	3.9	- 28	- 37
3	L125 × L229	- 0.67	2.8	4.0	- 22	- 30
4	L387 × L3690	- 0.63	1.8	3.1	- 14	- 41
5	L125 × L3690	- 0.60	1.8	3.2	- 14	- 45
6	L229 × L2991	- 0.59	2.2	3.2	- 21	- 31
21	(L2991 × L3690)[w]	0.48	2.2	2.4	- 5	- 10

[z]Negative effects imply transmission to progenies of low ACS. [y]ACS = antheridial cone splitting; MP = mid-parent. [x]BP = better parent. [w]Combination with the lowest SCA effect is included only for comparison.

Table 11. Distribution of gene action types for antheridial cone splitting (ACS) in a seven parent diallel experiment, AVRDC 1984.

Type	Number of Crosses	Advantage(%)over BP
Overdominance	3	- 22 to - 43[z]
Dominance	18	- 21 to + 14[y]
Total	21	

[z]Mean ACS of F1's are significantly lower than the better parent (BP). [y]Mean ACS of F1's are insignificantly different from that of BP.

Conclusion

A seven-parent diallel analysis of parental stocks with various levels of heat tolerance indicated that the trait (here expressed as percentage of fruit set) is conditioned by both additive and nonadditive acting genes. Similar results were obtained for antheridial cone splitting, an important component of heat tolerance. This congruence in results is interesting and is partly supported by the highly significant correlation ($r = -0.67$, $df = 26$) between fruit set and ACS tendency in the experiment.

The results imply that both conventional breeding methods which take advantage of additively acting genes, as well as F1 hybrid breeding, would be effective in developing varieties with improved levels of heat tolerance. With the latter, it is equally important to find combinations that also nick well for bacterial wilt resistance, since this is another important constraint to tropical adaptation. Based on previous results with diallel analysis of wilt resistance, it appears that this would be possible and could be secured, especially if both parents carry some levels of resistance.

Yield Trial of New Tropical Breeding Lines

Introduction

The tropical tomato breeding program continues to generate new lines for testing under hot and humid tropical conditions. In 1984, nearly 100% of the new lines that were tested

carried ToMV resistance as an additional improvement over the older tropical lines. In almost all cases, the new lines under test were derived through the SSD (single-seed descent) method which is usually carried out on a few elite crosses with appropriate modifications to speed up the generation turnover.

Materials and Methods

Four trial sets were carried out on different lines in the 1984 summer. Three of these trials involved new lines that were initially tested for heat tolerance and wilt resistance in 1983. Of these, two were preliminary trials of determinate lines and one of indeterminate lines. The fourth set was an observational trial of relatively newer SSD lines that were selected for heat tolerance from the 1984 late spring planting in the bacterial wilt nursery.

The preliminary trial of indeterminate lines consisted of 30 entries, and two of Taiwan's fresh-market cultivars as checks. This trial was sown on June 5 and transplanted on July 6, 1984 on a randomized complete block design with two replications. Individual plots consisted of two rows in a double-row raised bed, each 4.8 m long. Spacing between rows was 60 cm and between plants within rows, 40 cm apart. All entries were staked and lateral shoots were pruned. The number of developing fruit clusters was kept at seven per plant.

The preliminary trials of determinate lines were divided into two batches. Batch I which consisted of 29 entries was sown on June 5 and transplanted on July 6. The design was randomized complete block with two replications. Individual plots consisted of two rows, 4.8 m long each. Spacing between rows was 1.5 m and between plants within rows was 40 cm. Although all entries were determinate, plants were supported with short stakes to minimize fruit spoilage due to wet soil conditions. Batch II consisted of 25 entries and was sown on April 27 and transplanted on May 24. Plot size, design, and plant management were similar to Batch I.

The observational trial of newer SSD lines consisted of 41 entries. This trial was sown on June 19 and transplanted on July 17. The experimental design used was also the randomized complete block with two replications. Individual plots consisted of single rows, each 8 m long, with rows spaced 1.5 m apart and plants within the row, 40 cm apart. Again, the plants were supported with short stakes to keep them from touching the wet ground.

All entries in the preliminary yield trial were also planted in the bacterial wilt nursery to confirm their resistance levels. Four plantings were made consisting of determinate and indeterminate lines, each split into two batches. The plant pathologists prepared the wilt nursery by first planting a population of L390, susceptible host cultivar, and then artificially inoculating them with the wilt pathogen. After most of the plants died, they were turned under and the nursery was immediately planted to the test materials.

No further artificial inoculations were made and infection completely depended on the natural inoculum. In all cases, the randomized complete block design was used. Individual plots for determinate lines consisted of two rows, each 4.8 m long, and spaced 1.5 m apart. Spacing between plants within in the row was 40 cm. For indeterminate lines, individual plots consisted of two rows, each 4.8 m long, spaced 60 cm apart in a double-row bed. Spacing between plants within the row was 40 cm.

Results

Table 12 summarizes the performance of the best indeterminate tropical lines as compared with the fresh market check cultivars. In all cases, these lines outyielded the check varieties mainly because of their heat tolerance as evidenced by their higher percentage of fruit set. Marketable yield of the tropical lines was at least seven times higher than that of the best check cultivar, TSS#1.

Vine weight and maturity did not differ among entries, but fruit sizes of the tropical lines were still smaller than those of the check cultivars, except CL5915-206-2-2-0 which produced fruits of comparable size to that of TSS #1, though still significantly smaller than

that of KY301. This particular line is, however, not as heat-tolerant as the others, although it is still much better than the check varieties. In general, most of the lines showed relative susceptibility to bacterial leafspot (BLS) which has become a serious problem during the hot humid season. Only TSS #1 showed much less BLS infection.

Five untested lines belonging to the CL1131 series outyielded their sister line, CL1131-13-0-6, the best heat-tolerant line from last year's trials, in the Batch I preliminary test of determinate lines (Table 13). The main advantages of these lines over the check were in their vigor (as indicated by heavier vine weight) and in their relative resistance to bacterial leafspot (except for CL1131-65-13-0-1). In general, these new lines were not better than CL1131-13-0-6 in fruit size. Fruit set of all lines (except CL1131-65-13-0-1) were good with about 40% per cluster or better for most lines.

A much higher marketable yield was obtained from determinate lines in the Batch II trial (Table 14). Two lines had comparable yields to that of CL1131-13-0-6 even though their fruit set levels were significantly lower. CL5915-93-1-0 produced fruits at least twice the size of those of the other lines. Bacterial leafspot infection, which came rather late in the season, was not too severe to affect the outcome in this trial.

Table 12. Performance of indeterminate lines and heat-sensitive fresh market cultivars in the preliminary yield trial (AVRDC 1984).

Pedigree	Fruit Set (%)	Yield (t/ha)		Vine Weight (kg/plt)	Maturity (DAT)	BLS[z] Rating	Fruit Size (g)	
		total	marketable				mean	range
CL5915-553-6-4-0	50ab	31a	26a	0.5	79	5bc	23bc	14-37
CL5915-553-6-6-0	51a	29a	23a	0.5	79	5bc	26bc	19-44
CL5915-553-6-5-0	50ab	28a	22a	0.4	79	5bc	20c	10-30
CL5915-206-2-2-0	31c	27a	21a	0.5	78	4ef	37b	21-61
CL5915-16-7-4-0	44abc	26a	21a	0.4	78	5bc	28bc	22-47
TSS #1 (Check)	15i	3k	3n	0.6	80	2g	33bc	20-65
KY 301 (Check)	2n	0.6k	0.5n	0.9	80	7ab	80a	34-100
CV(%)	14	26	25	25	4	16	19	–

[z]BLS = bacterial leafspot

Table 13. Performance of determinate lines and the best-yielding heat-tolerant check line in the preliminary yield trial of Batch I (AVRDC 1984).

Pedigree	Fruit Set (%)	Yield (t/ha)		Vine Weight (kg/plt)	Maturity (DAT)	BLS Rating	Fruit Size (g)	
		total	marketable				mean	range
CL1131-26-1-0-1-0	53ab	40a	28a	0.6c-g	74f-h	1.5	17e-g	11-26
CL1131-65-13-0-0	37a-c	32ab	26ab	0.7c-f	74f-h	2.0	20b-g	15-34
CL1131-26-1-0	55ab	33ab	25a-c	0.6c-g	74f-h	2.0	16fg	14-25
CL1131-7-2-0-9	43a-c	25bc	23a-d	0.5d-h	72gh	1.0	19d-g	16-43
CL1131-65-13-0-1	32c	24cd	22b-c	0.4e-i	72gh	5.5	18e-g	19-32
CL1131-13-0-6(ck)	46a-c	17c-g	16f-i	0.2hi	64i	4.0	18e-g	1[illegible]-26
CL5915-153-3-3	53ab	23c-e	20c-f	0.4e-i	74f-h	5.5	24a-f	19-40
CV(%)	13	22	19	27	2		15	

Table 14. Performance of determinate lines and the best-yielding heat-tolerant check line in the preliminary yield trial of Batch II (AVRDC 1984).

Pedigree	Fruit Set (%)	DF[z]	DM[y]	Yield (t/ha)		Fruit Size (g)
				total	marketable	
CL5915-136-1-0	21b	13	82	38	35	34h
CL5915-93-1-0	23b	14	82	38	31	66a
CL1131-13-0-6(ck)	37a	12	76	37	34	30h
CV(%)	13	12	3	24	25	10

[z]Days to first flowering from transplanting [y]Days to maturity from transplanting.

The observational trial of new SSD lines led to the selection of several entries with comparable fruit set rates and marketable yields as the check line, CL1131-38-4 (Table 15). However, most of the new lines had improved fruit size over the check and had generally similar, if not better, vigor in practically the same growth duration. These newer lines have not yet been checked for bacterial wilt resistance and it remains to be seen whether the large fruited forms would carry adequate resistance.

The results of bacterial wilt screening by natural infection in the wilt nursery turned out to be undependable (Table 16). In almost all cases (with the possible exception of the sp/Batch II test), the level of mortality in the standard susceptible check was quite low and less than 50%. In the sp/Batch II test, this infection level reached only as high as 62% for the susceptible check. The heterogeneity of infection was apparent from the high coefficient of variation (CV) in almost all tests, except in the first planting. From these results, it was not possible, therefore, to confirm the resistance levels of the different lines entered in the preliminary yield tests.

Table 15. Best performing new SSD lines compared to the highest yielding check in the observational trial (AVRDC 1984).

Pedigree	Fruit Set (%)	Yield (t/ha)		Vine Weight (kg/plt)	Maturity (DAT)	Fruit Size (g)	
		total	marketable			mean	range
CLN95-77(D5)-1	44	44	37	0.7 bc	84 cd	33e	25-51
CLN91-139(D5)-1	34	43	36	1.0 abc	84 cd	41b-d	24-61
CLN91-392(D5)-3	46	44	36	0 9 bc	86 bc	44b	24-52
CLN91-392(D5)-1	43	44	35	1.1 abc	87 ab	50a	29-80
CLN91-392(D5)-2	46	41	33	1.6 a	87 ab	36de	22-50
CL1131-38-4(ck)	36	34	29	0.7 bc	84 cd	25f	19-39
CV(%)	8	17	20	33	1	7	–

Table 16. General information on the series of bacterial wilt screening experiments in summer 1984 with the natural infection method in the BW nursery.

Duration	Group	Number of Entries	CV(%)	Infection(%)[z]		
				range	(L390)	(L285)
5/17-7/11/84	sp' (I)	36	15	0-63	26	0
5/17-7/11/84	sp (I)	30	32	0-66	37	10
7/3 -8/22/84	sp' (II)	30	95	0-56	14	6
7/3 -8/22/84	sp (II)	36	79	0-62	62	7

[z]L390 = standard most susceptible check. L285 = standard most resistant check.

Conclusion

Four sets of hot season trials identified new lines with better yields than the check varieties (as in the case of the indeterminate tropical lines) or comparable to the best heat-tolerant check line (as in the case of the determinate tropical lines). In several cases, fruit sizes of the new lines were twice that of the check especially those in the determinate groups and had better, if not equal, vigor than the check. In the indeterminate group, the largest fruit size among the tropical lines was only comparable to one of the fresh market check cultivars; but it yielded at least seven times more. The main advantage of the tropical indeterminate lines over the fresh market checks was in the level of heat tolerance.

All new lines tested in 1984 carried ToMV resistance and represented one of the major improvements over the old tropical lines. An improvement in size also seems apparent, especially in the newer set of SSD lines, but the wilt rsistance of the relatively large-fruited forms needs to be confirmed.

No clear-cut results could be obtained from the screening of lines by the natural infection method in the wilt nursery. Unless the procedure is improved, the breeding program should resort to the old seedling-inoculation scheme.

Bacterial leafspot has become serious in the humid summer, and resistant sources need to be identified and incorporated into outstanding tropical lines.

Yield Potential of Tropical Lines with Improved Drainage

Introduction

The Soil Science Department has developed the 60-cm bed height system where the yields of older tropical lines during the hot and humid summer season have been demonstrated to be higher than those on the standard 30-cm bed height. A small experiment was conducted to compare the two bed-height systems.

Materials and Methods

Two groups of materials were tested in this experiment: five determinate lines and five indeterminate lines. Each group constituted separate experiments.

All materials were sown on June 20 and transplanted on July 16, 1984. The design was split plot consisting of two replications with bed height as main plot and line as subplot. Individual plots consisted of two rows in a double-row bed, each 4.8 m long and spaced 1 m apart. Spacing between plants within the row was 40 cm. The indeterminate lines were staked and pruned, and only seven fruiting clusters were maintained per plant. The determinate lines were also supported by short stakes to keep the fruits from sagging to the wet ground. Horticultural and fruit quality data were measured in the experiments.

Results

Table 17 shows a summary of the analyses of variance for the determinate lines including only those traits which showed significant variance source. As may be noted, bed height significantly influenced only fruit size and the extent of bacterial leafspot infection, but did not affect yield at all. In contrast variation due to genotypic differences between lines was significant in all cases.

CL5915-153-3-3 had the highest marketable yield and highest fruit setting rate (Table 18). Quality-wise, the lines varied in terms of pH, total soluble solids, and color.

The effect of bed height was manifested clearly on fruit size and BLS infection level (Table 19). Plots on the high bed gave significantly heavier mean fruit weight than those on the standard bed height. However, high-bed plots showed significantly higher BLS infection rate.

Among the lines, CL5915-223-2-2 and 5915-39-1-4 produced the heaviest fruits and had the least BLS infection (Table 20). In contrast, the two entries with the highest yields had the smallest fruits and the highest BLS infection rates. It is clear that in this experiment, fruit size and BLS infection did not play a significant role in determining the final yield of the lines.

Table 17. Summary of the analysis of variance for various characters in a line × bed height experiment on the determinate group (AVRDC1984).[z]

Source of Variation	Fruit Set (%)	DF[y]	DM[x]	Yield(t/ha) total	Yield(t/ha) marketable	Vine Weight (kg/plt)	Fruit Size (g)	pH	Soluble[w] Solids	Color	BLS[v]
Lines(L)	**	*	**	**	**	*	**	*	**	**	**
Bed Height(H)	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	*
L × H	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
CV(%)	9	13	3	20	14	23	5	2	9	8	9

[z]Data include only those which indicated significance for any variance source. [y]Days to first flowering from transplanting. [x]Days to maturity from transplanting. [w]Measured as °Brix. [v]Bacterial leafspot

Results from the indeterminate lines were nearly similar to the determinate lines (Table 21). Again, bed height clearly influenced fruit size. It did not affect the rate of BLS infection in this experiment, however. Days to flowering varied between bed heights and among lines.

CL5915-206-2-6 gave the highest marketable yield even though its fruit setting rate did not significantly differ from others (Table 22). In terms of quality, the indeterminate lines tended to have higher total soluble solids than the determinate lines in the other experiment. Again, variation in quality aspects between lines were apparent. Except in one line, the rest tended to be susceptible to BLS.

The high bed again significantly improved the fruit weight of lines (Table 23). Days to flowering were also earlier by two days.

Table 18. Comparative means for various traits of determinate breeding lines in the line x bed height experiment (AVRDC 1984).[z]

Breeding Line	Fruit Set (%)	DF[y]	DM[x]	Yield(t/ha) total	Yield(t/ha) marketable	Vine Weight (kg/plt)	pH	Brix[w]	Color
CL5915-153-3-3	46a	21a	86a	37a	33a	0.5bc	4.1ab	3.9b	2.2b
CL1131-13-0-6	36b	14b	75b	33a	26b	0.4c	4.2a	4.8a	1.7c
CL5915-223-2-2	17c	17b	88a	34a	26b	0.8ab	4.2a	4.8a	2.5a
CL5915-39-1-4	16c	16b	88a	23b	17c	0.7ab	4.2a	5.4a	2.6a
CL5915-204-1-2	10c	16b	89a	18b	13c	0.9a	4.0b	4.7a	1.9bc

[z]All means are averaged across factor B (bed height); includes only traits where bed height had no significant effects. [y]Days to first flowering from transplanting. [x]Days to maturity from transplanting. [w]Measured as °Brix.

Table 19. Comparative fruit size and BLS rating between low and high bed plots in the line x bed height experiment[z].

Bed Height (cm)	Fruit Size (g)	BLS Rating[y]
Low (25)	32b	5.5b
High (60)	37a	6.3a

[z]All means are averaged across factor A (determinate lines). [y]Bacterial leafspot.

Table 20. Comparative fruit size and BLS rating among determinate lines in the line x bed height experiment[z].

Breeding Line	Fruit Size (g)	BLS Rating[y]
CL5915-223-2-2	41a	4.2c
CL5915-39-1-4	41a	4.8c
CL5915-204-1-2	37b	5.8b
CL5915-153-3-3	28c	7.0a
CL1131-13-0-6	25d	7.8a

[z]All means are averaged across factor B (bed height). [y]Bacterial leafspot.

Table 21. Summary of the analysis of variance for various characters in a line x bed height experiment of the indeterminate group (AVRDC 1984).[z]

Source of Variation	DF[y]	Yield(t/ha) total	Yield(t/ha) marketable	Fruit Size (g)	Brix[x]	Titratable Acidity	Color	BLS[w]
Lines (L)	*	**	**	**	**	**	**	*
Bed Height(H)	**	NS	NS	*	NS	NS	NS	NS
L x H	*	NS	NS	*	NS	NS	NS	NS
CV(%)	2	21	23	10	7	12	9	18

[z]Data includes only those which indicated significance for any variance source. * = significant at P = .05; ** = significant at P = .01. [y]Days to first flowering from transplanting. [x]Measured as °Brix. [w]Bacterial leafspot.

Among the lines, CL5915-206-2-6 gave the highest mean fruit weight (Table 24). Days to flowering also varied significantly among lines even though the difference was only one day.

Table 22. Comparative means for various traits of indeterminate breeding lines in the line × bed height experiment (AVRDC 1984).[z]

Breeding Line	Yield(t/ha) total	Yield(t/ha) marketable	Brix[y]	Titratable Acidity	Color	BLS Rating[x]
CL5915-39-1-2	17b	14ab	5.9a	0.39bc	2.3a	6.0a
CL5915-206-2-6	24a	18a	4.4d	0.32c	2.1a	5.0ab
CL5915-270-1-1	8c	5c	4.8cd	0.40bc	1.6b	3.5b
CL5915-402-3-2	6c	5c	5.2bc	0.45ab	2.1a	6.0a
CL5915-214-1-5	15b	11b	5.8ab	0.53a	2.2a	5.2a

[z]All means are averaged across factor B (bed height), includes only traits where bed height had no significant effects. [y]Measured as °Brix. [x]Bacterial leaf spot rating.

Table 23. Comparative days to flowering (DF) and fruit size between low and high bed plots in the line × bed height experiment[z].

Bed Height (cm)	DF[y]	Fruit Size (g)
Low (25)	18a	32b
High (60)	16b	37a

[z]All means are averaged across factor A (indeterminate lines). [y]Days to first flowering from transplanting.

Table 24. Comparative days to flowering and fruit size among indeterminate lines in the line × bed height experiment[z].

Breeding Line	DF[y]	Fruit Size (g)
CL5915-39-1-2	17b	36bc
CL5915-206-2-6	18a	44a
CL5915-270-1-1	18a	24d
CL5915-402-3-2	17b	31c
CL5915-214-1-5	18a	38b

[z]All means are averaged across factor B (bed height). [y]Days to first flowering from transplanting.

Conclusion

Bed height did not affect the yield of the tropical lines during the humid summer season. It had no significant effect on almost every character measured, except fruit size which occurred consistently in both determinate and indeterminate lines, BLS infection (determinate lines), and days to flowering (indeterminate lines).

The main difference between this experiment and those of the Soil Science Department is the absence of the overhead plastic shade over the high-bed scheme. Under conditions of heavy rainfall, fruit setting among lines could be affected; and under shade, this effect would be absent. In the present experiment, fruit setting differed mainly among lines (in the determinate group); but bed height had no influence at all on the trait.

Regardless of the bed system, the highest marketable yield in the best determinate line was 33 t/ha. On indeterminate lines, the highest recorded yield was 18 t/ha.

International Trials

The tomato program distributed a total of 4,729 packets to 304 cooperators in 77 countries in 1984. This represented a 194% increase over the 1983 seed shipment. Most of

the lines distributed were improved types carrying ToMV resistance, in addition to the wilt and heat resistance that the older tropical lines carried.

A few cooperators filed reports on their trials. In many cases, these trials dealt with the old lines that were distributed before. There is not much feedback on the performance of the new tropical materials.

Malaysia

Mr. Tham Wai Fong of Pusat Pengeluaran Tanaman Pangan reported the performance of AVRDC's tropical lines in comparison to FP 59, a local check cultivar, in a trial conducted at Serdang (Table 25). Although CL1104-71-4-3 was comparable to the local check in terms of yield, its fruit size and wilt resistance were inferior. CL9-1-3 was considered the most acceptable as far as wilt resistance, and fruit size, shape, and color are concerned. FP 59 performed well, but its severe crack susceptibility makes it unacceptable in the local market.

Dr. A.M. Mokhtar of the Department of Genetics, Universiti Kebangsaan Malaysia, reported that two AVRDC germplasm carrying Tm1 and Tm2a genes for ToMV resistance are being used in his project.

Indonesia

The Taiwan Agricultural Technical Mission to Central Java tested 10 lines belonging to the CL1131 and 5915 series in a preliminary trial at BPP Borobodur, Kabupaten Megelang. Four lines stood out in terms of overall productivity and wilt resistance. The highest yield of 83 t/ha was obtained from CL1131-43-8-1 in a growth duration of 108 days. Very good yields were also recorded on three other lines (Table 26). The resistance to bacterial wilt of the best yielders ranged from moderate to high. Fruit sizes of two lines, CL5915-93-1 and CL1131-7-2-11, were also better than the others. Their wilt resistance were at best only moderate, however. Impressed with the performance of the lines, the Taiwan Mission sold harvest samples in the supermarket for consumer preference test.

Another AVRDC accession (L15) was released by the Central Research Institute for Horticultural Crops at Bogor under the name "Berlian". This line is highly resistant to bacterial wilt and can be grown in lowland elevations like the previous AVRDC lines, Intan and Ratna, released by the Indonesian national program in 1979.

Table 25. Best performing AVRDC lines compared with the local check at Serdang, Selangor, Malaysia.

Entry	Yield (t/ha)	Fruit Size (g)	Wilt Infection (%)
FP 59(Check)[z]	62	48	29
CL1104-71-4-3	61	34	37
CL9-1-3[y]	41	47	25

[z]Noted to be crack susceptible [y]Most acceptable in terms of wilt resistance, fruit size, shape, and color

Table 26. Best performing tropical tomato lines in a preliminary trial at BPP Borobodur, Kab. Magelang, Indonesia.[z]

Entry	Yield[y] (t/ha)	DM[x]	Fruit Size (g)	BW[w] Resistance
CL1131-43-8-1	83	108	42	R
CL5915-93-1	66	110	78	MR
CL1131-65-13-1	64	111	42	R
CL1131-7-2-11	62	108	68	MR

[z]No statistical analysis provided on summarized data [y]Range of yield (10 entries) = 33-83 t/ha [x]Days to maturity after transplanting [w]Range of bacterial wilt reaction (10 entries): S-R

Reunion

Using artificial inoculation, Institut de la Recherche Agronomique Tropical (IRAT) screened AVRDC lines or those derived therefrom for wilt resistance and compared their reactions to Roma, the check cultivar (Table 27). MST 25-7 showed the least wilt infection (37%) and is one of the two highest yielders among the lines screened. This line was derived originally from CL143 by researchers of the Sugar Industry Research Institute in Mauritius and has spread in use throughout the Indian Ocean islands. The other AVRDC lines were susceptible as expected. CL1561 lines are processing types not bred specifically for the tropical areas and, therefore, do not carry any resistance to bacterial wilt.

Table 27. Screening for bacterial wilt resistance of introduced tomato cultivars at Mon Caprice Station, Reunion 1983.

Cultivar	Wilt Infection[z] (%)	Production(g/plt)	
		total	marketable
Roma (check)	100	93	56
Rossol	93	470	310
MST 25-7[y]	37	1104	890
MST 32-1[y]	67	1085	890
CL1561-6-0-4-3-3	100	369	166
CL1561-6-0-19-1-4	100	317	159
L4094	100	591	341

[z]Data obtained from artificial inoculation. [y]Mauritius selections from CL143.

Liberia

Cooperators from the Central Agricultural Research Institute at Suakoko tested 10 AVRDC lines. The best yielding line was CL1131-7-2-0 which gave a substantially high yield over the local cultivar during the hot season (Table 28).

Table 28. Performance of the best AVRDC line and the local check in Suakoko, Liberia[z].

Entry	Marketable Yield[y] (t/ha)	Fruit Size (g)
CL1131-7-2-0	19	17
Local (check)	0	–

[z]No statistical analysis provided [y]Maximum yield attained.

Zimbabwe

Dr. M.D. Nzima of the Chidrezi Research Station tested 16 AVRDC lines against commercial cultivars from September to November 1983. Mean minimum temperatures during the duration of the trial ranged from 13.7° to 18.6°C. The best yielding AVRDC line was CL1131-38-4 (30 t/ha) as compared with Heinz 1370 (62 t/ha) (Table 29). There was no significant difference in fruit-setting rates between the two cultivars, implying that the main advantage of the tropical lines was not expressed during the trial.

Table 29. Performance of the best AVRDC line and the most outstanding entry at Chidrezi Station, Zimbabwe.

Entry	Marketable Yield (t/ha)	Fruit Set (%)
Heinz 1370	62 a	50
CL1131-38-4	30 c	56

Brazil

Dr. Simon Cheng of EMBRAPA-CPATU has been actively testing AVRDC tomato lines for adaptation to the Amazon, and found CL1131-38-4 the best line for the wet, low-light intensity season. In the 1983 wet season, CL1131-38-4 gave the highest yield (although not statistically different from others) over the local or introduced cultivars, and had no bacterial wilt infection (Table 30). The main problem is its small fruit size. It has, however, been actively used in their breeding program to develop improved cultivars for the Amazon. Its adaptability to dry season planting is acceptable; but other varieties, like Caraibe, are preferred for its larger fruit size (Table 31).

Table 30. Production, fruit weight, and wilt percentage among introduced cultivars evaluated during the 1983 wet season (January-May) in Belem-Para, Brazil.

	Days to First Harvest	Total Yield (t/ha)	Fruit Weight[z] (g)	Wilt (%)
Caraibe(1)	85	14	74 a	2
Caraibe(2)	85	13	68 a	14
Iguacu	89	7	38 b	71
Kada	97	9	40 b	32
CL1131-38-4	85	19	26 b	0

[z]Means followed by different letters are statisstically significant at p = 0.05 on the Tukey's test

Table 31. Production, mean fruit weight, and wilt percentage among introduced tomato cultivars evaluated in the 1982 dry season (August-December) in Belem-Para, Brazil.

Cultivar	Total Yield[z] (t/ha)	Fruit Weight[z] (g)	Wilt (%)
Caraibe	48 a	91 b	0
King Kong	50 a	108 a	12
Kada	36 b	70 c	16
CL1131-38-4	36 b	25 d	0

[z]Means followed by different letters are statistically significant at P = 0.05 on the Tukey's test.

Nepal

Mr. Reshi of the Institute of Agriculture and Animal Science (IAAS) at Rampur tested 16 AVRDC lines against the commercial cultivar Roma and local cultivar Rampur Sano during the summer season in the plains when the tomato price was at its peak (Table 32). Roma

Table 32. Performance of best performing AVRDC lines, local check, and a commercial cultivar in a summer trial at Rampur, Nepal[z].

Entry	Yield (t/ha)	DFH[y]	Fruit Size (g)	Fruit Set[x]	Leafcurl Virus[w] (%)	Taste Score[v]
CL1131-7-2	35	62	20 ef	H	24	2.8
CL1131-43-10-1	32	62	21 ef	H	38	1.6
CL1131-13-0-6	30	62	24 ef	H	78	2.2
CL1351-1-9-10	25	70	22 ef	M	0	2.4
Rampur Sano(local)	22	66	6 g	H	0	1.2
Roma	35	71	35 c	M	21	3.0

[z]All figures are averages of three replications. [y]Days to first harvest. [x]H = high set, M = moderate set. [w]All indications of virus infection are lumped together as leafcurl virus. [v]Rated from 0 = inferior taste to 3 = good taste

yielded the highest and scored best with the taste panel. CL1131-7-2, however, had the same high yield and a comparable taste acceptability, in addition to a shorter growth duration. According to Mr. Reshi, earliness is an important attribute for a variety to hit h Npal mark arly. CL1131-7-2 also had the added advantage of higher fruit set during the hot season because of its heat tolerance which Roma did not possess. It is apparent from the trial, however, that the his advantage was not fully expressed as Roma still yielded relativ ly well compared to the tropical lines.

Like the local variety, CL1351-1-9-10 had no virus infection. Fruit sizes of all lines tested were much larger than that of the local variety. Overall, Mr. Reshi assessed the potential of the tropical lines to be very good for production in the Nepal plains during the hot summer season. They are continuing the trials to come up with a recommendation to the local farmers.

Tomato Entomology

As in the past, entomological research activities in 1984 involved host plant resistance to insect pests, mainly tomato fruitworm, *Heliothis armigera* Hubner (Lepidoptera: Noctuidae), and cotton aphids, *Aphis gossyppi* Glover (Homoptera: Aphididae). In addition to these activities, entomologists also participated in a multidisciplinary research on sex pheromones in tomato fruitworm.

Fruitworm Resistance in Segregating Populations

Introduction

Two polyphagous insects, *H. armigera* and *Spodoptera exigua* Hubner (Lepidoptera: Noctuidae), are important pests of tomato in Southeast Asia. Both insects attack foliage in the early larval instars and fruits in their later instars. The major damage occurs inside the fruit. In 1980 entomologists confirmed fruitworm resistance for two *Lycopersicon hirsutum* f. *glabratum* accessions. AVRDC's plant breeder has crossed them with cultivated tomato to breed a high-yielding tomato cultivar with fruitworm resistance. In 1984 the backcross progeny, along with the parents, were tested to study the inheritance of resistance and select resistant entries which have good horticultural characters.

Materials and Methods

In late December 1983, three plants were selected from the BC2F1 population. These plants had relatively high fruitworm resistance and fruits bigger than those of the fruitworm-resistant *L. hirsutum* parent. The resulting BC2F2 population was screened for resistance to tomato fruitworm along with resistant and susceptible parents.

The pedigree of the materials screened was as follows:

1. CL5352BC1F1-1392 (bulk)-BC2F1-366
2. CL5352BC1F1-1392 (940)-BC2F1-458
3. CL5352BC1F1-1392 (940)-BC2F1-469
4. CL1591-5-0-1-2-0 (susceptible parent)
5. 76W-PH34417-A (resistant parent)

The seeds were sown in flats and the seedlings grown in the greenhouse for four weeks. In mid-March 1984 a 0.5 ha field was rototilled and worked into beds 1.5 m wide. Tomato seedlings were transplanted in a single row on each bed at a distance of 1 m between seedlings. One row of susceptible plants was planted after every nine rows of BC2F2 material, and resistant parents were planted along the edge of each row.

The crop was raised according to customary cultural practices, except that no insecticide was applied. At intervals, laboratory-raised fruitworm pupae were released to augment the ambient insect pest population. Each plant was evaluated twice by counting the fruitworm damaged and total number of fruits. Once during the season, the leaves were sampled and five first-instar larvae of tomato fruitworm were exposed over the leaves of each plant. Larval mortality was recorded at intervals during a five-day exposure period.

Results

Damage ranged from 0 to 100% infested fruits per plant. The bioassay of leaves showed 0 to 100% insect mortality. Based on these evaluations five plants with the least fruitworm damage were selected. To improve fruit size and plant type, more backcrosses will be made in the autumn of 1984 and the resultant progeny will be tested in 1985.

Conclusion

During the past two years of backcrossing and resistance screening, a fruitworm-resistant progeny with bigger fruits than the resistant parent was selected. However, fruits were still smaller than those of the conventional cultivars; therefore, further backcrossing and selection are necessary.

Mass-Rearing and Sex Pheromone Studies on Tomato Fruitworm

Introduction

The tomato fruitworm lays eggs on the foliage, and the larvae bore into the fruit and feed on it. Once inside the fruit, this insect cannot be controlled easily by conventional means. Frequent use of insecticides increases production cost, poses health hazards, and induces insecticide resistance. To develop a broadly based integrated management of this pest, AVRDC joined an interdisciplinary team sponsored by the National Science Council (NSC) of Taiwan in November 1983, to develop female sex pheromones to combat this pest. AVRDC volunteered to mass-rear this insect for isolation and sex pheromone characterization and to carry out field tests with virgin females and synthetic sex pheromone. In 1984, a mass-rearing technique was developed and field tests were initiate in December 1984.

Materials and Methods

A large number of fruitworm larvae were collected from tomato and corn in Tainan county and first reared on host materials, such as tomato fruits, corn ears, mungbean leaves, and water-soaked mungbean seeds. Since none of the natural foods were suitable for mass-rearing this insect, we switched to an artificial diet. The diet (Bio-Serv. Ct. #9219) is based on agar, casein, sucrose, wheat germ, salt mixture, cellulose, methyl parabenzoic acid, choline chloride, formaldehyde, and vitamin mixture.

In order to decide on the most suitable temperature requirements, tomato fruitworm larvae were reared on this diet at 20°, 25°, and 30°C. The right temperature was one with the shortest larval period and minimum mortality and abnormality.

For the mating and oviposition study, various containers were used ranging from 14 cm diam × 30 cm tall plastic jar to 60 × 104 × 114 cm nylon net cage. The ones that gave the maximum number of fertile eggs were selected for routine rearing work.

Results

All host plants prolonged larval period and produced high insect mortality and abnormalities. In many cases the larvae underwent six instars. On the other hand, the Bio-Serv diet gave better results: minimum abnormalities and mortality, greater pupal weight, and relatively shorter larval period. In all rearings the insect had only five larval instars. This diet, therefore, has become the standard food source for rearing tomato fruitworm.

Among the three temperatures tested, 25°C was most suitable. At this temperature the larval period, on average, lasted 16.5 days and the pupal period, 10 days. Larval mortality, which initially was 40%, was now reduced to an insignificant level. Mortality increased at higher temperatures.

Mating and oviposition behavior presented the greatest difficulty. Insects confined in small containers laid mostly infertile eggs. Larger containers, such as the 0.7 m^3 nylon net cage, solved the problem. Placing the host plant in the container, seemed to stimulate mating and oviposition. Adults were allowed to mate for 48 hours, after which they were confined in a small plastic container lined with paper. The females laid eggs on the paper, thus, making it convenient to transfer the eggs for hatching.

Conclusion

The introduction of an artificial diet has made it possible to mass-rear the fruitworm routinely. During 1984 over 14,000 insect pupae have been supplied to three organizations involved in NSC-supported projects for isolation and identification of sex pheromone.

Screening Hairy Tomato for Resistance to Aphids

Introduction

In 1982, AVRDC received a few segregating lines of tomato which had many trichomes on leaves and stems. In summer 1984 eight relatively pure lines were obtained from these plants for resistance screening to tomato fruitworm. Since the cotton aphid population during autumn was very high, these entries were screened for resistance to this insect.

Materials and Methods

Seeds of each entry were sown in plastic cups containing soil and compost mixture. The seedlings were raised for one month in the greenhouse. A 0.05 ha piece of land was rototilled and worked into 1.5 m wide beds along its length. These beds were further divided into three 10 m long plots. The seedlings were transplanted to the bed in a single row, with a distance of 0.4 m between plants in three randomly arranged replicates.

The crop was grown according to routine cultivation practices, except that no insecticide was used. Three weeks after transplanting, when the aphid population was very high, the number of aphids feeding on each of the 10 plant samples taken from each plot was recorded. The mean number of insects per 10 plant samples was analyzed according to Duncan's Multiple Range Test.

Results

A *Lycopersicon hirsutum* f. *glabratum* entry, 76W-P1134417-A, had the lowest number of aphids amongst all entries (Table 1). All hairy *L. esculentum* entries had significantly lower aphids than the standard susceptible cultivar TK 70 which does not have hairy leaves or stems. Some of the hairy entries were much less affected than the others.

Conclusion

Certain hairy entries of *L. esculentum* and wild tomato, *L. hirsutum* f. *glabratum*, showed moderate levels of resistance to cotton aphids. Since some entries were still segregating, these will be purified and screened further before being used for a resistance breeding program. Since 76W-P1134417 was least damaged and is already being used in the breeding program, the presently available and all future tomato fruitworm resistance breeding materials will also be screened for resistance to aphids.

Table 1. Aphid infestation of selected tomato lines.[z]

Entry Designation	No. of Aphids/ 10 Plants
76W-PI134417-A	15.3d
PT1394(2-2-2)-1-2-1-1	36.0cd
PT1629(30-8)-1-8-1-2	40.0cd
PT1626(30-8)-1-1-2-0	40.0cd
PT1627(30-8)-1-1-2-1	41.3cd
PT1630(30-8)-3-4-1-1	52.3cd
PT1631(2-2-2 x CL1131)-15-1-0	53.0c
PT1632(2-2-2 x CL1131)-15-1-1	91.7b
PT1633(2-2-2 x CL1131)-15-1-2	110.0b
TK70	239.7

[z]Transplanting date: Oct. 26, 1984; observation date: Nov. 6, 1984. The means of three replicates were used. Means of each entry followed by the same letter are not significantly different at the 5% level.

Tomato Pathology

Screening for Resistance to Cucumber Mosaic Virus

Introduction

Cucumber mosaic virus (CMV) is frequently found in the tomato production areas in Taiwan and other Southeast Asian countries. The fact that no commercial cultivars are available which carry resistance to CMV, prompted us to initiate a search for possible sources of resistance in the AVRDC germplasm.

Materials and Methods

The following accessions were tested with the PEET strain of CMV: Acc. No. 431, 457, 474, 482, 518, 520, 538, 539, 540, 632, 633, 636, 637, 641, 643, 644, 733, 734, 883, 916, 917, 919, 1033, 1042, 1065, 1474, 1534, 1540, 1541, 1601, 1696, 1723, 1746, 1747, 1959, 2107, 2692, 3063, 3231, 3234, 3276, 3682, 3683, 3837, 3967, 4253, 4269, 4270, 4363, 4777, 5339. The inoculum was prepared by homogenizing one part fresh CMV-infected tobacco (*N. tabacum* Xanthi) leaves in two parts (w/v) 0.01 M Na-phosphate buffer pH 7.0 with 1% thioglycollic acid added. The plants were kept in the greenhouse for symptom observation (shoestring, deformation, mosaic, and mottle). Symptomless plants and those showing very mild symptoms were tested by ELISA. The seeds were heat-treated at 78°C/48 hr to eliminate any seed-borne tomato mosaic virus (TMV).

Results

All accessions were found to be susceptible. However, two of the accessions (Accs. 1042 and 5339) contained more than 50% of uninfected plants whose seeds were collected for a second screening test.

Hairy Tomato as a Source of Resistance to Cucumber Mosaic Virus

Introduction

Resistance or even tolerance to cucumber mosaic virus (CMV) is not easily found in tomato or its wild relatives. While the search for resistance is ongoing, some hairy tomato lines are being evaluated as a possible source of resistance to the CMV vector.

The behavior of aphids on the hairy tomato was investigated last year, and it was found that although the average probe time was the same on the hairy and on the nonhairy tomato, the total probe time and the total probe numbers were significantly reduced on the hairy tomato. In the spring of 1984 the same hairy tomato lines were planted in the field and exposed to conditions of natural infection.

Materials and Methods

Four hairy tomato lines {(2-2-2)-1-2-1, (30-8)-1-1-1, (30-8)-3-4-1, (30-8)-2-5-1} and one cross between a hairy and nonhairy line {(2-2-2 × CL 1131)-16-1 F3} were evaluated in the spring of 1984 (date of transplanting to the field: March 15). Twenty plants of each line were planted in single rows at 40 cm distance. Plot size was 1 × 6 m. A randomized complete block design with four replications was used. The field was surrounded with two guard rows of tomato plants planted six weeks prior to the rest of the plants and artificially inoculated with the PEET isolate of CMV.

At 15, 32, 47, 61, 75, and 90 days after transplanting CMV infection was assessed in individual plants. Two leaves, one from the top and one from the bottom of each plant were collected and pooled for the ELISA test. The aphid population was counted at weekly intervals in the same field and in six other fields, (three fields planted to tomato, and one each to soybean, mungbean, and sweet potato), with the use of yellow Moericke trap pans filled with water (containing 0.1% TWEEN-20).

Results

By the end of the growing season (90 days after transplanting-DAT) the disease incidence reached almost 100% in the nonhairy check, but ranged only from 33.8% (Line 2-2-2)-1-2-1) to 76.3% (Line 30-8)-3-4-1) in the hairy lines (Table 1).

The infection rates (r), the rate of disease increase per unit time (sensu van der Plank), were always significantly lower (P = 0.05) for the hairy tomato lines (Table 2). For the F3 of a cross between the hairy tomato line (2-2-2) and a nonhairy line (CL1131), the r value was intermediate (r = 0.093519) between the parents, which had r values of 0.14643 and 0.030715, respectively. We assume that the intermediate r value is correlated with an intermediate number of hairs in the cross between the hairy and the nonhairy tomato.

The aphid population in the field where the experiment was planted, was not much different from that of the 50 other fields (Table 3). The highest rate of disease increase, which was measured between 47 to 75 DAT, was not associated with a high aphid population in the field. Aphid population was highest at 17 days after transplanting (Table 3) when CMV

Table 1. Reaction to CMV of hairy tomato lines and one cross between a hairy and nonhairy line under field conditions.

	Disease incidence (%) days after transplanting					
	15	32	47	61	75	90
Nonhairy check	0	0	6.4	20.5	88.5	97.4
Hairy × nonhairy	0	1.3	15.0[a]	40.0	72.5	78.8
Hairy 1 (22-2)-1-2-1	0	3.8	17.5	21.3	25.0	33.8
Hairy 2 (30-8)-1-1-1	0	3.8	13.8	35.0	56.0	67.5
Hairy 3 (30-8)-3-4-1	0	3.0	13.8	40.0	71.3	76.3
Hairy 4 (30-8)-2-5-1	0	2.7	21.8	29.9	57.1	67.9

[a]Each value represents the mean of four replicates.

Table 2. Progress of disease by days and infection rate (r) of CMV.

	Disease Progress (Logit)	Infection Rate (r)
Nonhairy check	-9.18318 + 0.14643 days	0.1463
Hairy 1 × nonhairy	-5.77563 + 0.093519 days	0.093519
Hairy 1 (22-2)-1-2-1	-3.1155 + 0.030715 days	0.030715
Hairy 2 (30-8)-1-1-1	-4.45224 + 0.0664766 days	0.0664766
Hairy 3 (30-8)-3-4-1	-5.17444 + 0.0816049 days	0.0816049
Hairy 4 (30-8)-2-5-1	-3.45798 + 0.0548405 days	0.0548405

Table 3. Aphid population in AVRDC fields during the time of the experiment.

Field	Aphid Population								
	days after transplanting								
	17	24	31	50	57	64	71	86	93
A[z]	47	12	18	11	9	9	11	3	3
B[y]	42	24	24	11	10	8	8	3	2

[z]The field in which the experiment was conducted. Average of aphid numbers collected in six Moericke pans. [y]Average of aphid numbers collected in six Moericke pans placed in six different fields throughout AVRDC.

was not yet detectable in the plants. This may indicate that, although the virus was transmitted by the aphids when the population was high, there was a latent period of approximately 15 days before the virus had multiplied within the plant tissues to a level sufficiently high enough for detection by ELISA. Also, a high aphid population in the field may not necessarily have to lead to a high incidence of CMV in the plants.

Conclusion

The hairy tomato lines show promise of lowering the rate of CMV development under field conditions. A second field test is needed to confirm the results and evaluate if hairiness should be considered a trait for use in the CMV resistance breeding program.

Screening for Resistance to Potato Virus Y (PVY)

Introduction

In recent surveys of the tomato production areas in Taiwan, the Philippines, Indonesia, and Malaysia, potato virus (PVY) was frequently detected. Generally, symptoms were mild mottle, yellowing, and veinclearing. Severe necrosis, yellowing, and reduction of the leaf lamina were, however, often observed when simultaneous infection with cucumber mosaic virus (CMV) and tomato mosaic virus (ToMV) was present. Because of the frequent finding of PVY and its synergistic reaction with other viruses, a screening was initiated to explore possible sources of resistance in the germplasm collection.

Materials and Methods

Because symptoms are mild in appearance, a screening method had to be developed to make them more pronounced and easily rated. The following method proved satisfactory: one part virus-infected *N. tabacum* Xanthi (PVY isolate 1103) was homogenized in five parts Na-Phosphate buffer (0.1M, pH 7.4). The plants were inoculated when the first true leaf was expanded. After two to three weeks, the top of the plant was cut between the 2nd and 3rd leaf, with alcohol-flamed scissors (to prevent contamination with TMV); and a second inoculation was performed on one of the newly emerging side shoots. The plants were kept in the greenhouse for two to three weeks after the 2nd inoculation when symptoms were clear and could be recorded visually. Symptomless plants or those showing inconspicuous symptoms were tested by ELISA.

Twenty to 30 plants were usually inoculated, or fewer when not enough seeds were available or when germination was poor. Seeds were heat-treated at 78°C/48 hr to eliminate seed-borne TMV.

The screening included 14 lines of *Lycopersicon* sp., reported to carry PVY resistance (Acc. Nos. VL70, VL68, VL80, VL100, VL101, VL102, VL103, VL104, VL105, VL106, VL110, VL111, VL112, and VL114), 61 randomly selected accessions comprising some wild

type tomato lines, *L. pimpinellifolim, L. hirsutum, L. glandulosum, L. glabratum, L. cheesemanii, L. peruvianum* and crosses between these (Acc. Nos. 101, 160, 431, 457, 474, 482, 486, 509, 538, 539, 540, 632, 633, 634, 656, 637, 643, 733, 883, 905, 913, 915, 916, 917, 919, 920, 1033, 1042, 1064, 1065, 1474, 1475, 1531, 1534, 1536, 1537, 1540, 1541, 1601, 1696, 1723, 2107, 2692, 2711, 2712, 3028, 3063, 3188, 3231, 3234, 3276, 3682, 3683, 3837, 3967, 4253, 4269, 4270, 4363, 4777, and 5339). A few breeding lines and commercial tomato lines were also screened (Acc. Nos. VL9, VL10, VL14, VL15, VL17, VL30, VL18, VL20, VL21, VL22, VL26, VL39, VL58, VL60, L124, L203, L4128, CL 1561-6-0-1-5-3, and CL 1131-00-43-8-1).

Results

Of all the tomato lines reported to be resistant to PVY, only one line, *L. hirsutum* (VL111) proved to be resistant to the PVY strain used in this screening (Table 4). In the screening of a random selection of AVRDC germplasm, only one accession, *L. hirsutum* (L3683) was found to be resistant, having a disease incidence of less than 10%. Seeds of resistant plants were collected and will be subjected to a second screening. None of the other tomato lines screened were resistant to PVY.

Conclusion

It appears that PVY resistance is not easily found in tomato and its wild relatives. That only one of the reportedly PVY resistant lines was resistant to our PVY isolate, may be explained by the fact that the screening methods used by other researchers did not produce clear symptoms, and that resistance was assessed only visually and not serologically, as was done in our screening. The possibility of strain specificity also exists. This will be further investigated.

Identification of an Unknown Virus on Tomato

Introduction

In the 1983 survey of tomato viruses, four POTY-virus isolates (T-697, T-1077, T-1082, T-704) were recovered, which did not react with PVY antiserum. Transmission, host range, and physical properties of these isolates were investigated. Attempts were also made to purify the virus for antiserum production which could be used in a survey to determine the frequency and distribution of this virus on tomato in Taiwan.

Materials and Methods

To determine the host range, three plants of each cultivar or species were inoculated when the first or second true leaf was expanded. The physical properties of the isolates were tested by the standard methods.

For serological testing, eleven antisera of PVY-group viruses reported to be able to infect tomato and antiserum of turnip mosaic virus (TuMV) were tested by immunosorbent electron microscopy (ISEM). The grids were floated for 5 min on the antiserum (1:1000), rinsed with Na-phosphate buffer and then floated for 15 min on the virus-infected crude plant sap. The grids were washed with 40 drops of double distilled water and stained with five drops of Uranyiacetate (2% in H_2O, pH 4.3) before they were viewed in the electron microscope.

For electron microscopic examination, small pieces of infected leaf tissue (*N. tabacum* Xanthi, *Petunia hybrida*) were excised, dehydrated in an ethanol series, and embedded in Spurr's plastic.

Table 4. Screening of reportedly PVY-resistant *Lycopersicon* germplasm for PVY resistance[z].

Coll. Acc. No.[y]	*Lycopersicon* Species		Disease Reaction[x] infected plants/ inoculated plant
VL70	*L. pimpinellifolium*	LA121, Dr. Rick	13/14
VL68	*L. hirsutum*	PI247087	8/10
VL80	*L. hirsutum*	LA1363	5/7
VL100	*L. esculentum*	PI126410	34/34
VL101	*L. esculentum*	PI127821	19/19
VL102	*L. esculentum*	PI127824	28/30
VL103	*L. esculentum*	PI117897	32/35
VL104	*L. esculentum*	PI128887	25/30
VL105	*L. esculentum*	PI131881	16/18
VL106	*L. esculentum*	PI91908	33/33
VL110	*L. esc.* × *L. pimp.*	PI195006	18/18
VL111	*L. hirsutum*	PI247087	2/21
VL112	*L. peruvianum*	PI128654	19/20
VL114	*L. per.* var. humifusum	PI127829	20/20

[z]Greenhouse inoculum: Isolate 1103, fresh leaves 1:3. Two inoculations: 1st inoculation at the first true leaf stage, 2nd inoculation 10 days later. [y]Virus indicator plant collection No. [x]All plants were checked by ELISA. ELISA-negative plants were retained for seed collection.

To determine insect transmission, aphids (*Myzus persicae*) were starved for 4 hr and were then allowed a 5-min acquisition feeding on systemically infected *N. tabacum* White Burley plants. Groups of five aphids were transferred to *N. glutinosa*.

For antiserum production, isolate T-1082 was purified using the scheme outlined in Fig. 1. Rabbits were given three intramuscular injections, at seven day intervals, of the purified virus emulsified 1:1 in Freund's complete adjuvant. The rabbit was bled one and two weeks following the last injection.

Results

The following hosts were systemically infected by each of the isolates: *Datura stramonium; L. esculentum* Delissa, CSTMW, and Bonnie Best; *L. pimpinellifolium* LA 121; *Nicandra physalodes; Nicotiana benthamiana; N. clevelandii; N. debneyii, N. glutinosa; N. sylvestris; N. tabacum* Xanthi Xanthi N.C., White Burley and Samsun N.N.; *Petunia hybrida* Grandifolia Minstrel Imp. and *Solanum nigrum. Ocimum basilicum* and *S. tuberosum* Duke of York, were the only hosts that produced local lesions with all isolates.

None of the isolates were able to infect *Capsicum annuum* Delray Belle, Florida VR-2, Yolo Y and Yolo Wonder; *C. frutescens* Tobasco, Greenleaf Tobasco and McIlhenny; *Chenopodium amaranticolor; C. quinoa; Cucumis sativus* Delikatess Robusta; *Nicotiana tabacum* V-20, *Phaseolus vulgaris* Pinto and Toperop; *Pisum sativum* Perfected Wales; *Solanum demissum* × *S. tuberosum* A-6; *Solanum melongena* Pingtung Long; *Solanum tuberosum* Cardinal; *Tetragonia expansa; Vigna unguiculata* Black; *Vicia faba* minor; *Zinnia elegans* Bright Scarlet and Tetra Ruffled Jumbo.

The thermal inactivation point of all four isolates was between 55° and 60°C. The longevity in vitro was 12 to 15 days for isolates 704 and 1077 and 15 to 30 days for isolates 697 and 1082. The dilution end point of isolates 704, 697, and 1077 was between 10^{-3} and 10^{-4}, and that of isolate 1082 was between 10^{-2} and 10^{-3}.

The unknown tomato virus was trapped on the EM grids only by the homologous antiserum and not by any of the other 11 antisera tested (Table 5).

Electron microscopic examination of thin sections showed pinwheels, typical of PVY-group viruses. As for transmission, aphid transmitted the virus in a nonpersistent manner. Virus purification gave sufficient virus yields for antiserum production.

Fresh infected leaves

↓

Homogenize in 0.3 M K_2HPO_4 buffer pH 7.2 containing 1% 2-mercaptoethanol and 0.01 M Na-EDTA (1 g of tissue/3 ml buffer)

↓

Leave for 1/2 hr at 4°C

↓

Strain through cheesecloth

↓

Add 10% n-butanol+chloroform (v/v) dropwise while stirring, stir 15 min. at 4°C

↓

Centrifuge at 2404×g for 15 min. (5000 rpm, GSA rotor)

↓

Centrifuge supernatant at 5.152×g for 10 min. (8000 rpm, GSA rotor)

↓

To supernatant add 6% PEG and 0.2 M NaCl; stir 60 min at 4°C

↓

Centrifuge at 13.322×g for 20 min. (12,000 rpm, SS-34 rotor)

↓

Resuspend pellet in 1/10 concentration of the initial buffer. (= resuspension buffer)
Centrifuge at 5.921×g for 10 min (8000 rpm, SS-34 rotor)

↓

Centrifuge supernatant at 46.866×g for 60 min. (27,000 rpm, Beckman 65 rotor)

↓

Resuspend pellet in resuspension buffer

↓

Layer on sucrose gradient (20-50%)

↓

Centrifuge at 57.859×g, 2 hr. (22,000 rpm, Beckman SW 25.1)

↓

Collect virus band

↓

Dilute with resuspension buffer

↓

Centrifuge at 50.413×g for 90 min. (30,000 rpm, Beckman 65)

↓

Resuspend pellet in 1 ml resuspension buffer

↓

Purified virus

Fig. 1. Purification scheme for T-1082.

Table 5. ISEM reaction of the tomato isolate T-697 with antisera of PVY group viruses.

Serum	No. of Particles Trapped[z]
Normal serum	6/0/0
T-697 AS (unknown tomato virus)	125/95/205
TuMV-AS	2/3/1
Perou tomato virus AS (Fribourg)	4/1/4
Pepper mottle virus AS (Purcifull)	5/1/2
Pepper mild mottle virus AS (Lastra)	0/3/0
Pepper veinal mottle AS (Brunt)	1/0/1
Tobacco etch virus AS 101	1/3/0
PVY-AS (GO-16)	0/5/0
PVA-AS (ALI)	0/1/1
Wild potato mosaic virus AS	14/6/2
Columbian datura virus AS (424)	5/4/4
Henbane mosaic virus AS (802)	1/1/2
Dioscorea Alata AS 443	0/3/0

[z]No of particles trapped per 50 viewing fields (= 500 μ^2)

Conclusion

The results of the host range study, electron microscopy, and serology indicate that this virus is a POTY virus, unlike those that commonly infect tomato. It is assumed that Isolate T-697 is a new POTY virus not described previously.

Survey for PVY and the Unknown Isolate 697 and an Investigation of the Cause of Severe Necrotic Symptoms on Tomato

Introduction

In previous surveys it was found that three viruses, TMV, CMV, and PVY, were most important in Taiwan. Tobacco etch virus (TEV) and pepper mottle virus (PeMV) were found only occasionally. Other viruses, such as potato virus X (PVX), tobacco ring spot virus, and tomato busby stunt virus, were not detected. Several virus isolates belonging to the poty virus group were also recovered which could not be identified. Antiserum to one of these isolates has been prepared. It was the scope of this survey to determine the prevalence of this virus and PVY in Taiwan. In addition, samples were also taken from plants with typical necrotic symptoms in an attempt to determine the causal agent of this disorder.

Materials and Methods

A total of 422 leaf samples were collected from Tainan, Pingtung, and Changhua areas. These included 206 samples which were surveyed only for PVY and the unknown virus, and 216 samples of plants showing necrotic streaks on stems; necrotic spots and ring spots on leaves; yellowing, mosaic, crinkle, and stunt of the top. The leaves were homogenized and tested by ELISA. Dilution of the coating gamma globulin was 1:1000 for the unknown virus (using antiserum to isolate 697) and 1:2000 for PVY. The dilution of the enzyme conjugate was 1:1000 for both viruses.

Results

The results of the survey for PVY and the unknown virus showed that approximately 2% of the 206 samples contained the unknown virus and 28%, PVY (Table 6). It appears

that this unknown virus may not be important in terms of distribution in Taiwan tomato plantings. Symptoms associated with this virus, such as mosaic, mottle, and veinclearing, were very similar to those caused by PVY. Additional plantings in the Pingtung and Changhua/Taichung areas are being surveyed before a final assessment of the importance of this virus will be made.

Fifty-two percent of the necrotic samples were found to contain PVY, 32% were found to be infected with CMV, and 20% contained TMV (Table 7).

It appears that PVY is most frequently associated with the necrotic symptoms. However, it is not likely to be solely responsible for such severe symptoms. We believe that the actual cause of the necrotic disease is a synergistic reaction of PVY with other viruses notably, CMV and TMV, since 18% of the samples were doubly infected with CMV and 14% with TMV. Double artificial inoculations with PVY and CMV isolates recovered from such necrotic samples produced severe necrotic symptoms in some of the inoculated tomato plants, often resulting in shock and death of the plant. When PVY or CMV isolates were inoculated singly, such symptoms did not appear. Double infection with PVY and TMV was not tested yet.

The possibility of involvement of other viruses is also considered. Forty-six of the necrotic field samples were also tested for tobacco ringspot virus (TRSV), tomato spotted wilt virus (TSWV), and potato virus X (PVX); however, none were positive for these viruses.

Table 6. Incidence of PVY and the unidentified virus in tomato plantings in Taiwan

Location	Total	PVY	Unidentified Virus
Pingtung	35	4	1
Tainan	171	54	3
Total	206	58	4

Table 7. Frequency of PVY, CMV, and TMV associated singly or in combination with the necrotic disease.

Location	Total	PVY	CMV	TMV	PVY CMV	PVY TMV	CMV TMV	PVY CMV TMV
Pingtung	60	32(26)[1]	16(10)	0	6	0	0	0
Tainan	78	40(6)	50(17)	10(9)	32	1	0	1
Changhua	78	41(10)	4(2)	31(0)	0	29	0	2
Total	216	113(42)	70(29)	41(9)	38	30	0	3

[1]Number in parenthesis is single infection only

Conclusion

The unidentified virus does not appear to be very important on tomato in Taiwan and thus will not be considered for resistance breeding at AVRDC. Evidence obtained from the survey strongly suggests involvement of PVY in causing the necrotic disease. Artificial inoculations indicate a synergistic effect between PVY and CMV. However, involvement of other viruses, for which we did not test, is also possible and this will be investigated.

Tomato Leaf Mold (*Cladosporium fulvum*)

Introduction

The leaf mold fungus (*Cladosporium fulvum*=*Fulvia fulva*), although generally considered to be of secondary importance, is thought to cause serious damage on tomato

in humid tropical climates. A major difficulty in working with this fungus is its high mutation rate and very slow growth on standard artificial media.

The present project has been initiated to search for a medium that promotes fast fungus growth, to make a survey of races present in the geographic area towards which the AVRDC breeding program is directed, and to evaluate the effectiveness of known resistance genes and of other reported sources of resistance.

Materials and Methods

Fourteen media were tested, each containing 20 g of the respective powdered compound, 20 g dextrose and 20 g agar per liter of medium (Table 8). The fungus was incubated at 24°C in the dark, and the diameter of the fungus colony was measured after four weeks. Each treatment was replicated three times.

For race identification, only one isolate (TCF-1) collected in Northern Taiwan was used in this study. It was tested on the standard set of differentials: Potentate, Sterling Castle, Vetomold, V121, and Purdue 135.

The plants were grown in plastic pots (two plants per pot; three pots per differential cultivar) in the greenhouse and inoculated at the three-to-five leaf stage by spraying them with a spore suspension of approximately 500,000 spores/ml. Following inoculation, the plants were enclosed in plastic cages and kept at 100% relative humidity for three days before they were transferred outside. The disease was scored approximately 20 days after inoculation, when symptoms were fully expressed. The following scheme was used for disease scoring: I: immune (no symptoms); R: resistant (some chlorotic or necrotic spots, but no sporulation); MR: moderately resistant (chlorotic spots with little sporulation); MS: moderately susceptible (moderate sporulation); S: susceptible (many heavily sporulating spots).

For evaluation of resistance, the same fungus isolate was used. It was tested on a set of tomato lines with reported leaf mold resistance using the same procedures as above (Table 9). For a wider exposure to races of the leaf mold fungus, the tomato lines were planted (one row per line, five to ten plants per row) in three locations in Taiwan: Hsinchu, Changhua, and Pingtung.

Results

Highly significant differences in growth speed on the different media were observed (Table 8). The diameter of the fungus colony after a four-week incubation period ranged from

Table 8. Growth (diameter) of *Cladosporium fulvum* on different media after a four week incubation period.

Medium	Average Diameter (mm)
Oatmeal dextrose agar	15.0 a[z]
Soybean dextrose agar	14.5 ab
Lima bean dextrose agar	13.3 abc
V8 juice agar	13.3 abc
Chick-Pea dextrose agar	13.0 bc
Azukibean dextrose agar	12.7 bcd
Lentil dextrose agar	12.7 bcd
Potato dextrose agar (ck)	12.3 cde
Cornmeal dextrose agar	12.0 cdef
Yeast extract peptone dextrose agar	11.7 cdef
Mungbean dextrose agar	11.0 defg
Rice dextrose agar	10.7 efg
Czapek dox agar	10.3 fg
Wheat dextrose agar	9.3 g
CV = 6.2%	

[z]According to Duncan's test, DMRT at P = 0.01

9.3 mm (wheat meal dextrose agar) to 15 mm (oat meal dextrose agar). The fungal growth was still slow, however, even on the best medium. No medium supported a much faster growth than the standard PDA.

Another method used since then to fasten inoculum production is to flood the petri dish with a water spore suspension to obtain many colonies scattered over the whole surface of the solid medium.

The fungus isolate used in this study was identified as race 7 according to the original race nomenclature system* or as race 2-3-6 on another system, which is gaining more and more acceptance in other parts of the world** (Table 9).

Table 9. Reaction of tomato lines to leaf mold (*Cladosporium fulvum* Isolate TCF-1).

Cultivar/Line	Gene(s)	Disease Reaction[z]	Origin	Cultivar/Line	Gene(s)	Disease Reaction[z]	Origin
Potentate	0	S	Hortic. Exp. St.	V473	Cf1Cf2	I	"
			Simcoe, Ontario	F101	Cf1Cf3	I	"
			Canada	Vineland	Cf2Cf3	S	"
Sterling Castle	Cf1	R	"	Vagabond	Cf2Cf4	I	"
Leafmold				Vinequeen	Cf2Cf4	I	Simcoe, Ontario
resister #1	Cf1	R	Royal Sluis Co.	Alex F14	?[y]	NS	"
			Holland	Bay State	?	I	"
Vetomold	Cf2	S	Simcoe, Ontario	Late Blight			
V121	Cf3	S	"	Resister #125	?	I	"
Purdue 135	Cf4	I	"	Okitu #8	?	R	"
Ontario 7717	Cf5	I	"	Ontario 794	?	I	"
PI 187002-1	Cf5	I	Royal Sluis Co.	Resistant			
			Holland	Moneymaker			
Ontario 7818	Cf6	S	Simcoe, Ontario	IVT	?	I	"
C164	Cf6	S	Royal Sluis	Shiko #471	?	NS	"
Ontario 7517	Cf7	I	Simcoe, Ontario	SWST	?	I	"
Ontario 7720	Cf7	NS	"	L21	?	S	AVRDC Tomato
Ontario 7522	Cf8	NS	"				Breeding
Ontario 7719	Cf9	R	"	L42	?	S	"
Ontario 792	Cf10	I	"	L94	?	S	"
Ontario 7515	Cf10	I	"	L203	?	S	"
Ontario 7716	Cf11	I	"	L221	?	S	"
Ontario 798	Cf12	NS	"	L265	?	S	"
Ontario 7813	Cf13	NS	"	L295B	?	S	"
Ontario 7814	Cf14	I	"	L302	?	S	AVRDC
Ontario 7910	Cf15	I	"				Seed Lab
Ontario 7816	Cf16	NS	"	L304	?	S	"
Ontario 796	Cf17	I	"	L336	?	S	AVRDC Tomato
Ontario 7518	Cf18	I	"				Breeding
Ontario 7519	Cf19	I	"	L337	?	S	AVRDC
Ontario 7520	Cf20	NS	"				Seed Lab
Ontario 7811	Cf21	I	"	L341	?	S	AVRDC Tomato
Ontario 7812	Cf22	I	"				Breeding
Ontario 723	Cf23	I	"	L360	?	S	AVRDC
Ontario 7819	Cf24	I	"				Seed Lab
5gR	Cf1Cf2	I	Royal Sluis Co.	L362	?	S	AVRDC
			Holland				Seed Lab

[z] S = susceptible, I = immune, R = resistant, NS = no score was taken [y] ? = gene(s) for resistance not known.

* Patrick, Z. A., E. A. Kerr, and D. L. Bailey. 1971. Two races of *Cladosporium fulvum* new to Ontario and further studies of Cf_1 resistance in tomato cultivars. Can. J. Bot. 49(2):189-193.

** Day, P. 1956. Race names of *Cladosporium fulvum*. Tomato Genetic Cooperative 6:13-14.

The tomato lines could only be evaluated at AVRDC, as natural infection by the fungus did not occur in any of the other three locations where the lines were planted. All known resistant genes with the exception of Cf2, Cf3, and Cf6 were highly effective against race 7. The same was true for the other tomato lines with unknown genes from Canada. However, all accessions reportedly resistant to *C. fulvum* in another AVRDC study were susceptible to this isolate (Table 9).

It is remarkable that the first race identified can already overcome three resistance genes (Cf2, Cf3 and Cf6), despite the fact that these genes have not been used in any breeding program in Taiwan. In areas where no leaf mold resistant tomato cultivars are grown, one would expect to find mostly race 0, the common race, attacking only cultivars possessing no genes for resistance.

Conclusion

An explanation as to why AVRDC accessions reportedly resistant to *C. fulvum* are now susceptible may be that these two studies used two different fungus races. Also, leaf mold could be confused with another very similar disease, black leaf mold caused by *Cercospora fuligena*. Visual assessment without microscopic examination could easily lead to an error in identification. So far, only one isolate was used in this study. More isolates have to be collected and identified before the best available sources of resistance can be chosen and a program pursued accordingly.

Testing Advanced Tomato Lines for Resistance to Leaf Mold Early Blight, and Bacterial Spot

Introduction

Leaf mold (*Cladosporium fulvum*), early blight (*Alternaria solani*), and bacterial spot (*Xanthomonas vesicatoria*) are known to be serious pathogens on tomato. They also frequently infect tomato in Taiwan. This preliminary study was undertaken to investigate whether resistance to the above-mentioned pathogens could already be found in AVRDC's advanced tomato lines.

Materials and Methods

Twenty-nine lines were screened in the greenhouse (two plants per pot, three pots per line) by artificial inoculation at the seedling stage (three-to-five leaves). Inoculation was done by spraying the following suspensions on the seedlings: *C. fulvum* (500,000 spores/ml); *A. solani* (mycelial suspension, the fungus did not sporulate on artificial medium); *X. vesicatoria* (10^8 CFU/ml).

Following inoculation, the plants were kept for three days in moistened plastic chambers (100% relative humidity) in the greenhouse (approximately 23°C continuous artificial illumination) before they were transferred outside.

Disease scoring for *C. fulvum* was done according to a notation scheme already described (see "Tomato Leaf Mold"). For *A. solani* and *X. vesicatoria*, the following was used: I: immune (no symptoms); R: resistant (a few minute spots, covering less than 5% of the leaf area); MR: moderately resistant (necrotic leaf area between 5 and 15%); MS: moderately susceptible (necrotic leaf area between 15 and 30%); S: susceptible (more than 30% of the leaf area necrotic).

Results

The results are summarized in Table 10. All lines tested in this study were susceptible to the three diseases. Should these diseases be severe in certain environments as in the 1984

Table 10. Reaction of advanced tomato lines to leaf mold, early blight, and bacterial spot.

Line	Reaction to[z]		
	leaf mold	early blight	bacterial spot
CL143-0-10-3-0-1-10	S	S	S
CL9-0-0-1-3-0	S	S	S
CL1104-00-29-1-0	S	S	S
CL1104-00-71-4-3	S	S	S
CL1131-00-7-2-0-9	S	S	MS
CL1131-00-13-0-6	S	S	MS
CL1131-00-26-1-0-1	S	S	S
CL1131-00-38-4-0	S	S	MS
CL1131-00-43-8-1	S	S	S
CL1131-00-65-13-1-1-0	S	S	MS
CL1561-6-0-5-1-3	S	S	S
CL1561-6-0-19-1-4	S	S	S
CL1591-5-0-1-7-0	S	S	S
CL2826-2-0-1-0	S	S	MS
CL5915-153D_4-3-3	S	S	S
CL5915-153D_4-3-2-0	S	S	S
CL5915-153D_4-3-4-0	S	S	S
CL5915-206D_4-2-5	S	S	MS
CL5915-206D_4-2-1-0	S	S	MS
CL5915-206D_4-2-2-0	S	S	MS
CL5915-222D_4-0-3	S	S	S
CL5915-222D_4-0-1-0	S	S	S
CL5915-222D_4-0-2-0	S	S	S
CL5915-229D_4-1-4	S	S	S
CL5915-229D_4-1-1-0	S	S	S
CL5915-229D_4-1-2-0	S	S	S
CL5915-553D_4-3-0	S	S	S
CL5915-553D_4-2-0	S	S	S
CL5915-553D_4-6-1-0	S	S	MS

[z]S = susceptible, MS = moderately susceptible

summer in Taiwan for bacterial spot, susceptibility would be a serious shortcoming of AVRDC's advanced tomato lines and would thus reduce the benefits of other desirable traits they possess. Disease resistance should, therefore, receive a higher emphasis in AVRDC breeding programs.

Evaluation of Sources of Resistance to Bacterial Spot in Tomato

Introduction

Last summer, a severe outbreak of bacterial spot (*Xanthomonas vesicatoria*) occurred in AVRDC tomato fields. This was the most serious disease of tomato during that season which often caused a complete defoliation of the plants. This prompted interest in sources of resistance to the disease.

Materials and Methods

Ten lines reportedly resistant to bacterial spot in the USA were tested for their disease reaction: PI 92863, 99782, 126923, 126932, 166365, 194308, 195006, 276423, 297317 (Regional

Plant Introduction Station, Ames, Iowa), and Hawaii 7998 (Florida). Three lines previously found to be susceptible were used as checks: Potentate, Vetomold, V121.

The plants were inoculated in the greenhouse (three to five plants per pot, five pots per line) with a bacterial suspension (10^8 CFU/ml) at the five-leaf stage. Plants were kept in a moisture-saturated atmosphere for three days before being transferred to the open, and the disease scored according to a scheme described previously (see "Testing of AVRDC Advanced Tomato Lines to Leafmold, Early Blight, and Bacterial Spot").

Results

All the lines tested were rated as susceptible (S) to the pathogen, except Hawaii 7998 which was rated resistant (R). A few spots were observed on Hawaii 7998, but they were much smaller and covered much less leaf area than on the other susceptible lines. Moreover, some segregation was observed within Hawaii 7998: a few plants were rated as moderately susceptible (MS) and were thus sorted out and discarded. Most of the plants were, however, resistant and were saved for use as source of resistance by the tomato breeding program.

Comparative Virulence of Different Isolates of *Corynespora cassiicola*

Introduction

Corynespora cassiicola causes not only a target spot on tomato, but also infects other plants. Although a large number of hosts have been reported for the fungus, evidence does exist indicating that certain strains of the fungus are host specific. During routine isolation and identification of fungal pathogens, isolates of *C. cassiicola* from tomato, soybean, sweet pepper, and tobacco were obtained, thus enabling a small study to be conducted on the comparative virulence of these isolates on different hosts.

Materials and Methods

Routine tissue isolations of *C. cassiicola* were made from naturally infected tissues of tomato, sweet pepper, soybean, and tobacco. These isolates were designated TOT, SPT, SBT, and TBT, respectively (Table 11). Cultures were maintained on potato dextrose agar (PDA). The inoculum was prepared by washing conidia from 10-day-old PDA cultures which had been incubated at 28°C under illumination for 12 hr each day. The spore suspension was filtered through a single layer of cheesecloth, and the concentration was adjusted to 20,000 to 30,000 spores/ml of water. Tween 20 was added at a rate of 1 drop/100 ml to facilitate wetting of the conidia and leaves.

Four plants were used in the cross-inoculation studies: tobacco (*Nicotiana benthamiana*), sweet pepper (*Capsium frutescens* cultivar Blue Star), soybean (*Glycine max* cultivar TN4), and tomato (*Lycopersicon esculentum* cultivar TK70). An atomizer was used to spray one-month-old plants with the spore suspension until the upper and lower leaf surfaces, as well as the petioles and stems, were uniformly wet. All plants were covered with plastic bags for 48 hr. Mature green tomatoes (TK70) were also inoculated after first surface-sterilizing them

Table 11. Sources of *Corynespora cassiicola*.

Isolate	Infected Host	Place Collected	Year
TOT	Tomato/fruit	AVRDC, field	1982
SBT	Soybean/leaf	AVRDC, field	1983
SPT	Sweet pepper/leaf	Doe-luo, field	1983
TBT	Tobacco/stem	AVRDC, greenhouse	1984

with 50% alcohol. The tomato fruits were inoculated by inserting the mycelium with a sterile needle.

Results

The comparative virulence of each of the isolates is presented in Table 12. On tomato, the TOT isolate was the most pathogenic, whereas the other isolates produced only small lesions. The pepper isolate was not pathogenic on this pepper cultivar, but infected the tobacco plants. In tomato fruit inoculations, only the TOT isolate caused the disease, producing a large lesion covering approximately 1/3 of the fruit in 11 days.

In general, cultures of *C. cassiicola* were most pathogenic on the host from which they were isolated, displaying a pattern of host specificity already alluded to in the literature. The exception was sweet pepper which was resistant to all isolates tested, including the SPT isolate. This may be due to host plant resistance, and we do not know if this is the same cultivar as the original host. The cultivar of tobacco used in this experiment also seemed to be susceptible to all the isolates used in the test. This specificity was also evident in the tests on tomato fruit, where only the tomato isolate was able to cause a fruit rot.

Table 12. Comparative virulence of four isolates of *Corynespora cassiicola*.

Isolate	Disease Severity[z] on			
	tomato	soybean	sweet pepper	tobacco
TOT	5	2	2	4
SBT	2	5	2	4
SPT	2	1	1	4
TBT	2	3	2	4

[z]Disease severity: 1 = Weak virulence, a few pinpoint lesions; 2 = Many pinpoint lesions with some coalescing; 3 = Many coalescing lesions, lesions appearing clearly on stems; complete yellowing of lower leaves; 4 = Heavy water-soaking of leaves and blighting of lower leaves; 5 = Blighting of entire plant.

Conclusion

The existence of host specific strains of *C. cassiicola* indicates that care will have to be exercised not only in selecting isolates to use in screening for resistance but in characterizing the nature of host plant resistance as well.

Studies on Bacterial Wilt of Tomato

Introduction

Bacterial wilt of tomato (caused by *Pseudomonas solanacearum*) is a major constraint to tomato production in warm, humid climates. Continuing efforts to find reliable methods of quantifying bacterial wilt resistance have continued into 1984.

Field plantings were placed out twice this year. As before, test material was planted in fields that had been artificially infested with *P. solanacearum* by inoculating susceptible material planted as a first crop. This method had produced satisfactory results in 1983. Greenhouse studies continued with infectivity titrations in the stem (three sets) and one with the inoculum placed in the soil. The materials and methods and results section for these will be presented below.

Materials and Methods

A field was naturally infested with *P. solanacearum* by planting it first with L390 on March 28, inoculating clipped leaf with a suspension of bacteria on April 27 and May 3,

and allowing the plants to die. New beds were formed and the test material planted. A prolonged rainy period, however, prevented planting of the test material for about one month, and they were not transplanted until June 18. To supplement the amount of bacteria in the soil, the test tomato transplants were inoculated by dipping roots in *P. solanacearum* (OD = 0.2) before transplanting. The number of wilted plants were counted at regular intervals. The regression analysis was used with incidence as the dependent variable and time as independent variable. A second planting was conducted in a similar manner with the test material transplanted (without the root dip inoculation) on August 20.

Results

More plants wilted this year than in last year's experiment. Very resistant lines (such as L285) did not wilt much; lines with intermediate reactions last year often had replicates in which all plants died. The linear component of the quadratic fit did provide a good measure of wilt resistance, with susceptible materials showing a much faster increase in wilt incidence than the more resistant lines (Table 13). As in last year's study, no wilt developed in the second planting, and this one was abandoned.

Conclusion

Root-dip inoculation was a very harsh treatment and may provide a partial explanation for the increased severity of wilt in this year's experiment.

Infectivity Titrations

Introduction

The general method for stem-inoculation infectivity titrations was to grow seedlings, inoculate them with various concentrations of bacteria, and then record the number of wilted plants at several intervals. Three plantings were done with inoculation direct into the stem, and one was done with inoculation via the root system.

Materials and Methods

Stem inoculations were done by inserting a sterile wire into the leaf axil of the plant and then replacing it with a micro-pipette containing the bacterial suspension. For the root inoculations, a suspension of bacteria was poured on the soil after first slightly damaging the root system with a spatula.

For the first planting seeds were sown on December 14, 1983, and inoculated on January 11, 1984 with seven levels of bacteria having concentrations ranging from 10^2 to 10^8 CFU/ml. Each plant received 100 μl of the suspension directly into the stem. These plants were kept in a heated greenhouse to facilitate disease development.

In the second test, the seeds were sown on February 15, and the plants were inoculated on March 22 with 12 levels of bacteria having concentrations ranging from $10^{2.5}$ to 10^8 CFU/ml. In this case the amount of bacterial suspension was decreased from 100 to 50 μl, was also injected directly into the stem, and the plants kept in the heated greenhouse.

In the third test, the seeds were sown on April 26 and inoculated on May 30. Each plant received 50 μl of one of 12 levels of inoculum ($10^{2.5}$ to 10^8 CFU/ml). These plants were also kept in the heated greenhouse.

The plants received 2 ml of bacterial suspension after having their root system damaged in two sites by the insertion of a 6 by 35 ml spatula. Seed was sown on July 18, and the plants were inoculated on August 8. Twelve concentrations of bacteria were used, ranging from $10^{2.5}$ to 10^8 CFU/ml. In all infectivity titrations, the data were analyzed with a BASIC

program that converted it to probit of incidence and fitted the probit lines with an iterative procedure. For selected lines, graphs of the raw data, probits, and expected probits were made with the use of a related program. ED 50 values were calculated (Tables 14-17).

Results

Infectivity titrations appeared to be a satisfactory method of determining relative resistance and susceptibility of tomato lines to bacterial wilt. Within a given test set, the material considered resistant based on field tests showed a higher ED 50 than that reported to be susceptible. Lines intermediate in their resistance in the field also showed ED 50 values intermediate between resistant and susceptible.

Stem injection showed very large differences. In the second set of stem injections, the susceptible material showed ED 50 values around 10^4 CFU/ml, whereas the projected ED

Table 13. Testing selected tomato lines for bacterial wilt resistance in the field.[z]

Variety	Intercept	Linear	Quadratic
L1	-.6960	.1061	-.0018
L8	-.2802	.0795	-.0014
L15	-.8545	.1132	-.0019
L95	-.1593	.0196	-.0003
L96	-.2630	.0397	-.0007
L240	-.4953	.0496	-.0008
L285	-.2008	.0165	-.0003
L366	-.5650	.0677	-.0011
L373	.2594	.0515	-.0010
L390	.2821	.0471	-.0009
L766	.5199	.0333	-.0006
L1629	-.9013	.1117	-.0020
L1937	-.0472	.0369	-.0007
L3490	-.0902	.0617	-.0011
L3690	-.6728	.0666	-.0011
L3705	-.3295	.0500	-.0009
L4670	-.2783	.0352	-.0005
L204	-.2990	.0403	-.0007
CL206	-.1588	.0684	-.0012
CL330	-.4992	.0707	-.0012
CL390	-.0396	.0588	-.0010
CL402	.2219	.0348	-.0006
CL455	-.1048	.0114	-.0002
CL551	-.1722	.0739	-.0012
MT1	.0848	.0377	-.0007
MT2	-.5014	.0460	-.0008
MT3	-.5421	.0673	-.0011
MT4	-1.028	.1364	-.0024
MT5	-.1295	.0708	-.0013
MT6	-.7442	.0991	-.0017
MT7	-.9743	.1403	-.0025
MT8	-.3016	.0269	-.0004
MT9	-.2387	.0454	-.0008
MT10	-.2058	.0428	-.0007
PT858	-.5303	.0995	-.0017
PT862	-.6337	.0980	-.0017
PT913	-.1475	.0795	-.0015
TK70	.3840	.0348	-.0006
TM103	-.0789	.0699	-.0013

[z]Summer 1984.

50 for resistant lines was around 10^{15} CFU/ml. This latter figure lay outside of the range of values obtained from the experiment, and caution should be exercised when making conclusions.

Differences between resistant and susceptible materials were not very large in the root inoculations. For resistant L285 and susceptible L390 the $\log_{10}$ ED 50 values were 11.94 and 6.48, respectively. This narrower spread would also mean more difficulty in separating lines that have intermediate resistant reactions. At the same time, however, root inoculation was more realistic and represented a more natural pathway for the bacteria to enter the plant.

Table 14. ED 50 values from infectivity titrations, with the inoculum applied to the stem.[z]

Line	LOG ED 50		
	day 9	day 15	day 26
L8	5.60	5.05	4.52
L15	7.47	7.09	7.07
L95	4.02	3.48	3.48
L96	6.89	6.17	6.10
L245	6.38	5.80	
L285	7.57	7.57	7.57
L366	6.80	6.33	6.25
L373	6.45	5.97	5.54
L390	5.93	4.49	4.40
TK70	5.65	5.05	4.46

[z]January 1984

Table 15. ED 50 values from infectivity titrations with the inoculum applied to the stem.[z]

Line	LOG ED 50				
	day 11	day 15	day 19	day 22	day 26
L8	18.77	5.05	7.04	6.25	6.04
L15	7.90	6.96	6.51	6.51	6.51
L95	8.58	8.72	8.99	9.61	9.61
L96	8.60	7.36	6.59	6.41	6.41
L245	9.56	5.89	4.97	3.86	3.64
L285	15.07	15.07	15.07	15.07	15.07
L366	9.25	7.82	6.22	5.91	5.62
L373	8.20	5.98	4.90	3.87	3.87
L390	8.87	6.96	5.86	5.14	5.08
TK70	8.04	6.25	5.87	5.50	5.31

[z]March 1984

Table 16. ED 50 values from infectivity titrations with the inoculum applied to the stem.[z]

Line	LOG ED 50				
	day 16	day 23	day 19	day 22	day 26
L1	18.77	5.05	7.04	6.25	6.04
L8	5.78	5.27	6.51	6.51	6.51
L15	6.66	6.42	8.99	9.61	9.61
L96	8.67	8.72	6.59	6.41	6.41
L245	4.93	4.40	4.97	3.86	3.64
L285	11.18	11.18	15.07	15.07	15.07
L366	6.44	6.27	6.22	5.91	5.62
L373	4.14	4.02	4.90	3.87	3.87
L390	3.28	4.50	5.86	5.14	5.08
TK70	6.66	6.47	5.87	5.50	5.31

[z]May 1984

Table 17. ED 50 values from infectivity titrations, with the inoculum applied to the soil.[z]

Line	LOG ED 50			
	day 8	day 12	day 16	day 20
L1	7.61	7.19	7.02	6.91
L8	8.73	8.09	7.63	7.63
L15	8.15	7.70	7.43	7.32
L95	10.12	9.66	9.35	9.35
L96	9.28	8.90	8.70	8.81
L240	7.26	7.10	7.01	7.01
L245	8.58	8.10	8.03	8.03
L366	8.51	7.43	7.09	7.06
L373	7.12	6.67	6.50	6.50
L390	7.14	6.99	6.99	6.99
L766	6.59	6.35	6.27	6.21
L1629	8.72	8.25	8.06	8.01
L1937	8.51	8.11	8.09	8.02
L3490	9.33	9.65	8.83	8.73
L3690	9.95	9.67	9.33	9.33
L3705	12.14	11.29	10.86	10.86
L4670	9.64	9.01	8.94	8.92
CL551	8.73	7.40	7.00	7.00
TK70	8.11	7.64	7.47	7.47
L96[y]	8.94	8.34	8.21	8.14
L285[y]		15.50	11.94	11.94
L390[y]	7.33	6.84	6.60	6.48

[z]Summer 1984 [y]These lines were retested at a later date. Exercise care in comparing these results with those above.

Conclusion

While infectivity titrations with either stem or root inoculation appeared to determine host plant resistance to bacterial wilt, there were some drawbacks. The effect of climatic or environmental differences was large enough to prevent a given line from having an ED 50 that remained constant from test to test. Even the January and March tests gave quite different results for the same line, though both were conducted in a greenhouse where the temperature was closely regulated. Differences in solar radiation, watering, absolute temperature range, and other environmental factors could well be the cause of these differences. At present, we lack the facilities to pursue these questions more closely.

This method also requires a large number of plants. With 10 sets of plants per level, and 12 levels of inoculum, 120 plants are required. These plants should be uniform as well, since a mixed population will require more plants at a given level, or suffer from a poorer fit (and more difficult comparisons). Computer software that allows for the comparison of lines is being located, and will hopefully allow more sophisticated analyses to be conducted.

Late Blight on Tomato

Introduction

Late blight of tomato (caused by Phytophthora infestans) is a problem of tomatoes grown in highland tropical areas. We have been investigating a tomato line, L1197, that shows partial resistance to this pathogen. The lesions on this line were not smaller, but they were fewer. This past year's studies were aimed at confirming this resistance in the field. Another laboratory study was conducted to determine if the infection rate (the number of spores that infect divided by the total number) was lower in this line than in TK70.

Materials and Methods

Four-week-old transplants of both L1197 and TK70 were placed in the field on February 10. There were two plots of each variety, or a total of four plots. All plantings were inoculated on March 22 by placing four infected plants in each plot. An overhead sprinkler irrigation was applied for 5 min six times a day to facilitate disease development. Disease ratings were taken at regular intervals according to a modified assessment key for a potato disease. These data were analyzed through a linear regression of logit disease over time.

Ten-week-old detached leaves of two entries, TK70 and Acc. 1197, were placed on a stainless steel net which was fitted into a 35 × 25 x 8 cm plastic box, 2 cm above the bottom. Four to five wet toilet papers were put on the bottom of the plastic boxes which contained two tomato leaves each for two different entries.

Sporangia of *P. infestans* previously isolated from diseased plants in Puli, were grown on leaflets of TK70 in a 20°C incubator which was lighted for 12 hr and darkened for 12 hr a day. Ten days after inoculation fresh sporangia were washed by D.W. and sieved through a double layer of cheesecloth. For 2.5 hr, a 10 ml filtrate with a large number of sporangia and 0.1% potato tuber extract (30 g potato tube in 100 ml water) was kept at 10°C to induce zoospore liberation. To separate the smaller zoospores from empty and nongerminated sporangia, which can not pass through the filtering tissue, the incubated suspension was filtered again. In order to determine the concentration, 1 ml of filtered suspension was mixed with 1 ml 8% formol for killing and fixing the zoospores. The concentration of zoospores required for the test was determined with a hemocytometer, and serial dilutions were made from deionized water with 1/100 potato tuber extract.

The inoculum was applied on the abaxial surface of the leaflets in 5 μl droplets with an Eppendorf micropipet. The suspensions were adjusted to 10 different dosages : 120, 90, 60, 42.5, 36, 30, 25, 18, 12, and 6 zoospores/droplet. They were dropped on the right-hand side of 10 different leaves separately, and replicated (randomized sequence) on the left-hand side. After inoculation, the plastic boxes with leaves were enclosed in plastic bags to retain moisture and stored in the greenhouse in a 20°C incubator (12-hr light and 12-hr darkness). The toilet papers were wetted every day. Data were taken four days after inoculation.

Results

In the susceptible line, TK70, the epidemic began by April 10; and by April 25, the disease severity was so high that no more data were taken. The rate of disease development was .11, and the fit had an r^2 of .97 (Figs. 2 and 3). No disease developed in L1197 despite the presence of the inoculated plants and the overhead sprinkler irrigation.

For TK70, a very good fit was obtained (chi-square value of 6.43065), with an ED 50 value of 26.5023 and a slope of 3.2503 (Table 18). For L1197, probit analysis was unable to explain these data, and the best fit line had a very large chi-square value-41.8167 with 7 df.

Conclusion

This is a good technique for determining infection rate of zoospores of P. infestans, but more work is required before it can be used on L1197. Additional factors seem to be responsible for the growth of the fungus in the plant. This may be the resistance of the tomato line itself, which is causing difficulty in distinguishing between resistant and susceptible reactions. False "susceptible" reactions may have occurred in some of the sites, which led to too many positive responses, which in turn caused the probit line to fit poorly.

L1197 displays excellent resistance under field conditions, although the actual reasons are still unknown. In the absence of correlated characteristics and the lack of knowledge about the components of resistance, screening will have to be continued under field conditions.

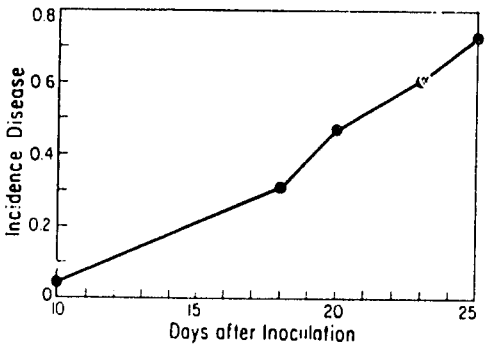


Fig. 2. Development of late blight in the susceptible tomato TK70.

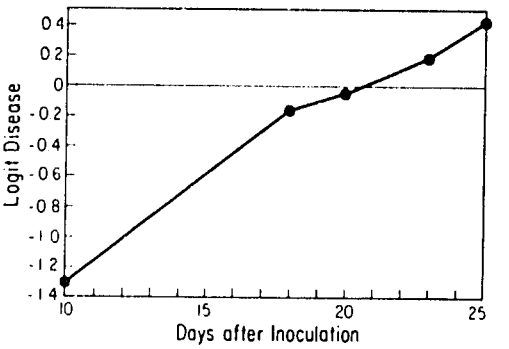


Fig. 3. Development of late blight in the susceptible tomato TK70 (disease transformed to logit).

Table 18. Infectivity titrations of *Phythophthora infestans* on tomato.

Zoospores per Drop	TK70		L1197	
	Site Number	Positive Sites	Site Number	Positive Sites
120	40	40	35	24
90	37	36	18	14
60	35	31	26	10
42.5	40	32	40	31
36	40	27	48	35
30	40	21	27	12
25	40	15	11	2
18	40	8	38	21
12	40	9	42	4
6	40	0	33	0

Tomato Physiology

Effect of Temperature on the Stability of Tomato Flower Membranes

Introduction

The flower is affected by high temperature. At present, the mechanisms controlling the heat tolerance of a flower's components are still not clear. Since the membrane may have a central role in the cellular response to stresses, the extent of its damage is commonly used as a measure of tolerance to various environmental stresses in plants.

The present study examined: 1) the effect of high temperature on membrane stability of tomato leaf tissues, anthers and pistils; and 2) the variability of membrane stability of anthers and pistils of heattolerant and heat-sensitive tomatoes under different temperatures.

Materials and Methods

Seedlings of L124, L387, L3958, L3982, CL1131F_5-26-1-0, CL1131F_5-43-8-1, and CL1131F_5-65-13-0-1 were transplanted to the clay pots on July 5, 1984. During the growing period, plants were subjected to mean maximum/minimum temperatures of 33.3°/23.0°C. On July 25, half of the plants were moved into a greenhouse (42.3°/23.4°C); the other half were kept outside (33.3°/23.0°C).

On August 1, plants with different stages of floral development and the third expanded leaves from the tip were harvested to determine membrane stability. Bud anthers and pistils five days before anthesis (DBA), 2 DBA, and 0 DBA (at anthesis) were separately removed. Ten to 12 anthers and pistils and 20 leaf discs were placed in test tubes with 20 ml of deionized water and incubated at 50° and 100°C for 20 min. Tissues were removed from the solution before measuring conductance.

The plants used in the second investigation were heat-sensitive (L123 and L124), heat-tolerant (L3957, L3958, CL1131F_5-43-8-1, and CL5915-153D_4-3-3) and parthenocarpic (Severianin) tomatoes. Seedlings were field transplanted on July 23, 1984. A randomized complete block (RCB) design with four replications was used. Flowers buds (5 DBA, 2 DBA, 0 DBA) were separately harvested from the field from August 27 to September 6. Mean maximum and minimum temperatures (°C) from field planting to sampling were 31.4 (23.6 to 33.4) and 24.4 (22.0 to 26.0), respectively.

Anthers and pistils were separately removed from the flower buds at 2 DBA and 0 DBA. Flower buds at 5 DBA were removed without separation from the flower buds. Twelve anthers, pistils, or anthers with pistils were placed in test tubes with 10 ml of deionized water and incubated for 90 min under temperatures of 20°, 25°, 30°, 35°, 40°, 45°, 50°, and 100°C in a reciprocal shaker at a frequency of 40 cycles /min. The anthers and/or pistils were then removed from the solution.

The conductance of ion leakage in remaining solutions were measured with YSI Model 32 Conductance Meter. There were three replicates for each measurement. The extent of membrane injury caused by temperature was assessed from the change in the leakage between specific temperature and 100°C.

Results

The extent of pistil damage, regardless of developmental stage and growing temperature, was the highest (Table 1). Leaf tissues from plants grown at low temperatures had the least damage. Anthers at 5 DBA had a higher damage rate than 2 and 0 DBA, maybe because of the difficulty in separating anthers and pistils at 5 DBA and the resulting damage before incubation. Plants grown under high temperature conditions clearly had higher membrane damage of both leaf and reproductive tissues than under low temperatures. The results suggest that the reproductive tissue is most sensitive to high temperature.

The second investigation aimed at finding the critical temperature for membrane damage showed that high temperature increased the leakage of electrolytes from anthers and/or pistils (Fig. 1). All anthers and pistils at 2 and 0 DBA were more leaky than those at 5 DBA. Pistils were more leaky than anthers at all developmental stages. For anthers with pistils at 5 DBA and anthers at 0 DBA, more than 50% heat injury occurred at 50°C. The slope between 45° and 50°C was steepest for anthers at 0 DBA, indicating that anthers are particularly sensitive to temperatures in this range. On the other hand, for both anthers and pistils at 2 DBA and pistils at 0 DBA, more than 50% heat injury occurred at 45°C. Some discrepancies between the first and second investigations may be due to the difference in growing temperatures.

When comparing the leakage of electrolytes among entries, the leakage from anthers of 0 DBA, and anthers with pistils of 5 DBA from heat-tolerant CL1131F_5-43-8-1 and CL5915D_4-153 was less than the rest of entries (Table 2). The least heat injury to anthers at anthesis of heat tolerant CL1131-0-0-43 and CL5915-153D_4, was most noticeable at 50°C (Fig. 1). This result suggests that the anther membranes of heat-tolerant tomatoes were highly stable. Since the reproductive organs were obtained from the field-grown plants under high

Table 1. Heat injury (%) of membranes in leaf discs, anthers, and pistils from tomatoes grown under high and low temperatures[z].

Temp (°C)	Leaf	Anthers			Pistils		
		5 DBA	2 DBA	0 DBA	5 DBA	2 DBA	0 DBA
42.3/23.4	31**	59*	36	30**	77	79	74*
33.3/23.0	13	45	32	21	76	73	65

[z]Mean of seven entries, each with three replications. Significant difference at 5% (*) and 1% (**) level, F test

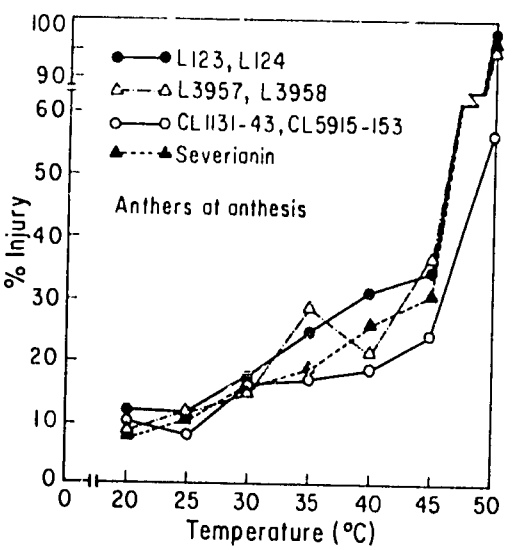


Fig. 1.
Heat injury (%) of anthers taken from different tomato entries and incubated at various temperatures. Each point represents the mean of two entries, except on Severianin.

Table 2. Leakage of electrolytes (m mhos/cm/g dry wt) from anthers, and anthers with pistils at 50°C[z].

Entry	Anther with Pistil (5 DBA)	Anther (2 DBA)	Anther (0 DBA)
L120	7.94a	13.98a	13.78ab
L124	7.79a	10.01d	12.26b
L3957	8.39a	12.02bc	15.36a
L3958	8.10a	11.00cd	12.45b
CL1131F$_5$-43	5.14c	9.34d	5.24d
CL5915-153D$_4$	6.40b	12.69a-c	9.72c
Severianin	7.72a	13.40ab	13.81ab

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

temperature, it is very likely that genotypes selected as heat-tolerant are actually genotypes with heat-tolerant anthers at anthesis.

Conclusion

High temperatures increase the membrane permeability of both tomato leaf and floral organs. The different responses to temperature of tomato anthers and pistils of various varieties in terms of membrane stability pose a potential method for the study of heat stress on the reproductive process and screening for heat tolerance. Since other mechanisms of reproductive process should also be considered in heat tolerance of tomato, the comparative responses of membrane permeability may not constitute a final classification of their heat tolerance. However, a re-evaluation of selected tolerant genotypes under high temperature stress for the identification of specific processes that do well in terms of membrane stability may be desirable. Genotypes with stable reproductive membranes are desirable, especially when one considers that the effect of high temperature on tomato is usually sublethal and slow.

Effect of High Temperature on Proline Content in Tomato

Introduction

Proline accumulates in response to environmental stress. The objectives of this research were to 1) determine if temperature causes the accumulation of proline; 2) investigate the extent of proline accumulation in different plant parts; 3) find out if variability in proline content is related to heat tolerance; and 4) clarify the role of proline in pollen germination.

Materials and Methods

Seedlings of L124, L387, L3958, L3982, CL1131F$_5$-26-1-0, CL1131F$_5$-43-8-1, and CL1131F$_5$-65-13-0-1 were transplanted to clay pots on March 13, April 9, and June 11, 1984, respectively. One week before sampling for proline determination, the plants grown outside the greenhouse were divided into two groups; one group was left outside the greenhouse, and the other was placed inside under high temperature treatment.

Twenty-one plants of each entry were separated into three replicates. Right after a week of high temperature treatment, the floral buds were separately sampled according to flower development, i.e., five to four days before anthesis (DBA), 2 to 1 DBA, and at anthesis (0 DBA). The third fully expanded leaflets from the top were also harvested. Flower buds of different developmental stages were separated into anthers and pistils. Leaflets, anthers, and pistils were weighed, extracted, and determined for proline content on the fresh weight basis

In the investigation for the role of proline in germination, fresh anthers of CL5915 379D$_4$-1-4-0 and CL1131F$_5$-65-13-0-1 were collected on the day of anthesis from the field

Pollen was brushed off from the anthers into an Abdalla and Verker germination media with or without proline (0.45, 0.85, and 1.25 M) for 5 min at room temperature, and then placed either at 40°C or remained at 27°C for 10 min. before diluting with the same germination medium without proline and incubating at 27°C. Germination rate was determined after 3 hr of incubation. Another investigation was conducted to check the effect of proline at lower concentrations (1 mM and 5 mM) on pollen germination of L387, CL5915-136-1-0, CL5915-153D_4-3-3 and CL5915-229-3 at 28°C.

Results

There was an accumulation of free proline in the leaves of plants grown at high temperature (Table 3). The magnitude of difference in leaf proline is greater among plantings of low temperatures than among those under one week of differential temperature treatment before sampling. Other investigators had also shown free proline accumulations in leaf tissue in response to other environmental stresses, and attempted to relate this increase to environmental tolerance or to use it as an indicator of stress level. However, no consistent genotypic differences were found in free proline level of tomato leaf tissue among seven entries examined. Our results suggest that in order to obtain consistent proline response to temperatures, strictly controlled temperature is required.

High proline level with ambient high temperature may be used as an indication of high temperature stress. However, since the flower is most sensitive to high temperature which causes the reduction in fruit set, the change in concentration of free proline in floral tissues with time of planting and high temperature is also determined and shown in Table 3. The data indicated that proline concentration in anthers increased with increasing developmental stage. This trend can be observed in anthers of plants in the three planting dates. Moisture content is constant during anther development, so this increase may be solely proline.

Within the same planting time, anthers obtained from plants grown at high temperatures had significantly lower proline concentration. This is further supported by the fact that in the three plantings, the anthers from the hot-season plants (June 11 to July 23) had lower proline concentration than the cool-season ones (March 13 to April 24). However, we found no consistent genotypic differences in the proline levels of anthers in relation to the different heat-tolerant levels of these entries. This may be due to the fact that we were not able to grow plants under strictly controlled environmental conditions.

In another experiment with CL5915-153 conducted in growth chambers, the results confirmed the findings that proline level in anthers increased with increasing developmental stage; and high temperature reduced its level (Table 4). The first finding did not apply to pistils, however, but the second did.

Proline levels in these reproductive organs were higher than in the leaf tissue, ranging from 4-to 40-fold. It has been suggested that proline accumulation was of survival value during environmental stress. Since the flower is most susceptible to high temperature stress, high proline level may be necessary to maintain its physiological function. The apparent reduction

Table 3. Effect of temperature on proline content (μ mole/g fresh wt) of tomato anthers and leaves[z]

Planting	Temp. (°C)	Leaves	Anthers		
			4 DBA	2 DBA	0 DBA
March 13	37.0/22.3	0.61ns	3.35*	12.13*	20.17ns
	28.9/18.4	0.54	8.53	18.41	20.73
April 9	45.0/21.0	1.67*	3.19*	13.20*	19.10*
	36.5/18.6	1.05	8.00	18.20	22.40
June 11	41.2/24.3	1.35*	4.94*	5.36**	8.99**
	33.7/23.0	0.81	5.71	6.89	10.74

[z]The average of seven entries; significant difference within the same planting at 5% (*) and 1% (**) level, F test.

of proline accumulation in anthers by high temperature indicates that proline could have an important function in the viable pollen development under adverse high temperature conditions.

Since the role of proline in anthers is difficult to assess under *in vivo* conditions, data in Table 5 indicated that the addition of proline to the germination medium made pollen more resistant to high temperature stress. Proline at lower concentrations in the medium also promoted pollen germination at room temperature (Table 6). These results suggest that the high proline concentrations found in tomato anthers may indeed confer tolerance to germinating pollens at unfavorable temperatures, thereby enhancing the chance of successful fertilization.

However, there are added complications to be strengthened out before a more definite answer about the mechanism of proline action in the anther can be given. Present studies could not detect genotypic differences in anther proline at different developmental stages in relation to genotypic differences in terms of heat tolerance (i.e., fruit yield and fruit set ability at high temperature). The fact may be complicated by fluctuating temperature or other environmental factors before sampling and analyzing. Furthermore, previous results showed that most of the pollens from heat-sensitive tomatoes were rendered nonviable at high temperatures. Whether proline plays any role in these aspects remains to be seen.

Table 4. Effect of temperature (°C) on proline content (micro-mole/g fresh wt) of anthers and pistils from CL5915-153[z].

Organ	Stage	25.0/18.0	30.0/25.0	33.0/23.3
	5-4 DBA	8.51c	6.17	7.12b
Anther	2-1 DBA	a14.94b	b8.25	b8.58ab
	0 DBA	a20.61a	b8.66	b10.86a
	5-4 DBA	a6.74	b4.47	c2.49ab
Pistil	2-1 DBA	a4.51	a6.86	b1.98b
	0 DBA	a4.84	ab3.98	b3.06a

[z]Letters to the right of numbers: mean separation within columns by Duncan's Multiple Range Test, 5% level. Letters to the left: mean separation within rows by DMRT, 5% level.

Table 5. Effect of heat and proline addition on tomato pollen germination (%).

Temp (°C)	Proline (mole/l)	CL5915-379D4-1-4-0[z]	CL1131-F5-65-13-0-1[z]
40	0	0.2f	0.7f
	0.45	10.1e	3.7e
	0.85	25.9cd	7.2cd
	1.25	23.4d	5.5de
27	0	1.8f	3.9bc
	0.45	41.6a	10.5b
	0.85	31.7b	10.5b
	1.25	29.7bc	13.3a

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

Table 6. Effect of proline addition on tomato pollen germination (%)[z].

Entry	0 mM	1 mM	5 mM
L387	14.5b	19.1a	19.1a
CL5915-136-1-0	9.8c	13.8b	18.5a
CL5915-153D4-3-3	9.1b	10.0ab	12.1a
CL5915-229-1-3	16.8b	19.5a	18.0ab

[z]Mean separation within rows by Duncan's Multiple Range Test, 5% level.

Conclusion

Proline concentration in the tomato anther increased with advancing developmental stage, but decreased with increasing temperature. In the leaf tissue, it accumulated as the temperature increased, but its concentration was lower than that in anthers and pistils. The exact role of proline in anthers and pistils is not clear. However, the addition of proline to the germination medium made pollen more resistant to high temperature. These results suggest that high proline concentrations in the anther may confer resistance to the anther or pollens at unfavorably high temperatures.

Studies on Tomato Pollen Respiration

Introduction

It is necessary to establish the relationship between proline and metabolic events important to pollen germination. Proline stimulates normal respiration of plant tissues and removes any inhibitory action exerted on oxygen uptake. Furthermore, an adaptive role for stress-induced betaine accumulation has also been inferred in stress environments. The purpose of this study was to determine the effect of temperature on the respiration of germinating pollen in the culture medium with or without proline or betaine.

Materials and Methods

Seedlings of L387 and CL5915-153D_4-3-3-0 were field planted on September 26, 1984. A randomized complete block (RCB) design with three replications was employed, each replicate having 60 plants. When the plants had four to five clusters, the flowers were collected on the day of opening from each replication for 25 days, starting on October 21. Pollen was collected by shaking it off the flower into a pollen collector in the laboratory. Mean maximum and minimum temperatures from field planting to the last sampling of pollens were 30.7 + 1.3 and 21.7 + 1.6, respectively. The pollen was stored in airtight polyethylene bags together with silica gel to reduce humidity, and kept in a freezer at -15°C.

On the day of respiration measurement, the pollen was thawed for 15 min before weighing. Respiration was measured manometrically with a Gilson Differential Respirometer. The standard culture medium consisted of H_3BO_3, $Ca(NO_3)_2$, and sucrose at 100 ppm, 150 ppm, and 20%, respectively. The amount of media used in each respiration flask was 1.7 ml. Respirations were measured at 20°, 26°, 32°, and 38°C. At 32°C, the medium was added with 5 mM proline or betaine. There were either three replications (10 mg pollen/replicate) or four replications (7 mg pollen/replicate) for each measurement. At the termination of respiration measurements, the media with pollen were observed for pollen germination under a microscope at 200× magnification.

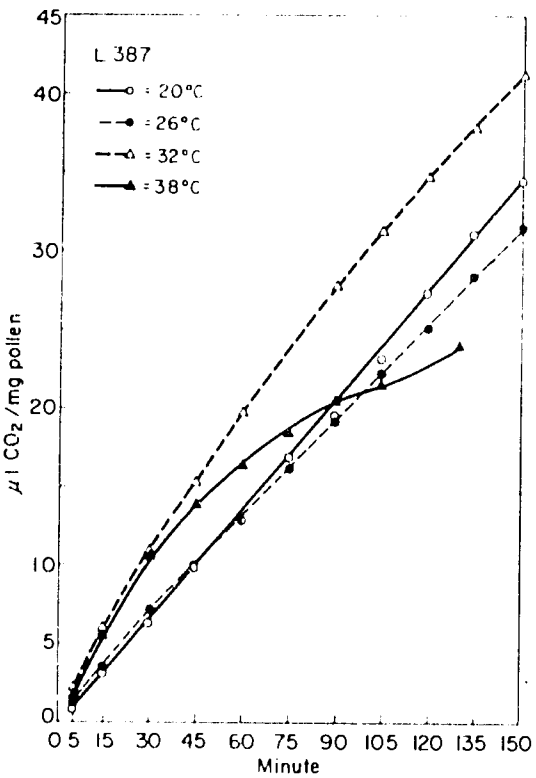
Results

Pollen respiration of both L387 and CL5915-153D_4-3-3-0 responded quite differently under different temperature conditions. With L387, respiration increased constantly at 20° and 26°C, and remained high thereafter (Fig. 2). At 32° and 38°C, respiration increased rapidly about 30 min, and then started to decrease faster at 38°C than at 32°C. For CL5915-153D_4-3-3-0, respiration increased constantly at 26°C and remained high thereafter; whereas respiration was low at 20°C throughout the measuring period (Fig. 3). Pollen respiration increased rapidly for 30 to 45 min at 32 and 38°C; however, it decreased rapidly thereafter, especially at 38°C. Regardless of incubation temperature, pollen respirations of L387, in general, were higher than those of CL5915-153D_4-3-3-0. High respiration rates

resulted in a high percentage of pollen germination. The average pollen germination rate was higher in L387 than in CL5915-153D_4-3-3-0 (Table 7).

Studies have shown an association of anther proline reduction with high temperature and betaine accumulation in plant tissue under stress. In this study, both proline and betaine tended to enhance pollen respiration and germination of poorly respiring and germinating pollen of CL5915-153D_4-3-3-0 at 32°C (Fig. 4). The exact role of proline and betaine in pollen respiration is not clear. However, it was suggested that in germinating pollen the free proline reserves could be directly incorporated into structured proteins, which are necessary for pollen growth.

In terms of fruit set, L387 was usually heat-sensitive and CL5915-153D_4-3-3-0 was heat-tolerant. However, the pollen of L387 clearly had higher pollen respiration and germination rates than that of CL5915-153D_4-3-3-0 in this experiment. The pollens of both entries were collected when the temperature was favorable for fruit setting. Proline and betaine reserves might already be high enough in L387, to satisfy the basic requirements for the germinating pollen at different temperatures. We suppose that the level of these reserves was low in CL5915-153D_4-3-3-0 even under favorable conditions, but that the addition of free proline or betaine to the medium had a strong stimulatory effect.



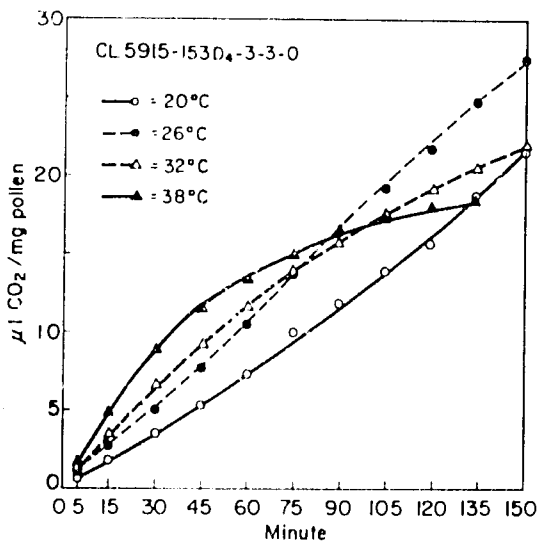


Fig. 2.
CO_2 release of germinating tomato (L387) pollen. Each point is the average of three or four replicate Warburg flasks.

Fig. 3.
CO_2 release of germinating tomato (CL5915-153D_4-3-3-0) pollen. Each point is the average of three or four replicate Warburg flasks.

Table 7. Pollen germination (%) of tomatoes under different temperatures with or without proline and betaine[z].

Treatment	L387	CL5915-153D_4
20°C	45ab	18abc
26°C	34b	6c
32°C	50a	16bc
32°C + 5 mM proline	52a	32a
32°C + 5 mM betaine	34b	24ab

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

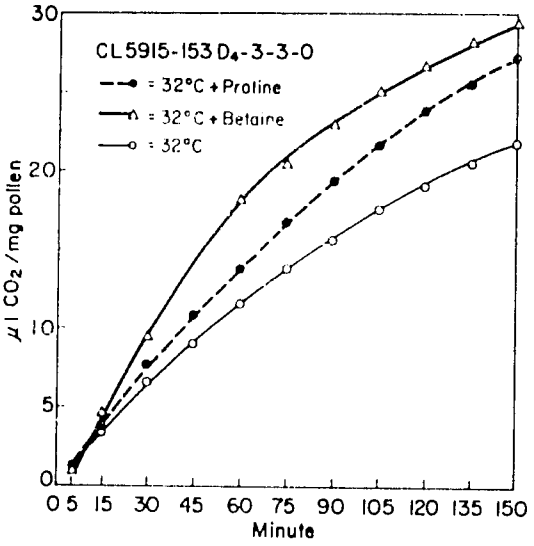


Fig. 4.
CO_2 release of germinating tomato (CL5915-1530$_4$-3-3-0) pollen in the medium containing betaine or proline. Each point is the average of three or four replicate Warburg flasks.

Conclusion

Germinating pollen of L387 and CL5915-153D$_4$-3-3-0 exhibited high rates of respiration at 20° and 26°C. High temperatures at 32° and 38°C clearly inhibited pollen respiration and germination. In general, CL59 153D$_4$-3-3-0 had lower pollen respiration and germination than L387. However, the addition of proline or betaine to the medium of CL5915-153D$_4$-3-3-0 enhanced pollen respiration and germination.

It is difficult to ascertain the role of proline and betaine in this comparative study of heat tolerance in L387 and CL5915-153D$_4$-3-3-0 because the pollen of these tomatoes were collected under favorable temperature conditions. Nevertheless, the experimental results clearly reinforce our earlier assumption concerning the important role of free proline in the tomato reproductive processes at high temperature.

In Vitro Study of Floral Bud Development

Introduction

Due to lack of environment-controlled facilities at AVRDC, studies on high temperature stress and screening for heat tolerance in tomato are sometimes rather difficult. The use of the *in vitro* technique for various physiological studies on tomato floral buds has made it possible to carry out experiments which could be time-consuming, cumbersome and sometimes impossible under field conditions. Since the tomato floral bud is most sensitive to high temperature, the present study was conducted to explore the best tomato floral-bud culture, and examine floral bud development under normal and high temperature conditions.

Materials and Methods

Seedlings of L387 and CL5915-153D$_4$-3-3-0 (CL 5915) were field-planted on September 26, 1984. A randomized complete block (RCB) design with three replicates was employed; each replicate had 60 plants. Mean maximum and minimum temperatures throughout the growing season was 30.2 ± 1.5 and 21.8 ± 2.2, respectively.

Sizes of floral buds at six days before anthesis (DBA), 4 DBA and 2 DBA were predetermined by tagging and observation. When the plants had five to six clusters, floral buds with pedicels were excised at 6 DBA, 4 DBA, and 2 DBA, in that order, at 2-day intervals.

Various sterilizing methods, bud preparations, and media were tried. The best procedure is briefly described as follows:

Floral buds were sterilized with 0.1% $HgCl_2$ for 5 min, and then rinsed three times with sterile, distilled water. Excessive moisture was removed by pressing the buds against sterile tissue paper. Floral buds were cut above the abscission zone and their sepals removed before they were transferred to test tubes containing a modified MS medium. The medium contained 10% sucrose and 1% agar. In one of the high-temperature bud culturings, 1 mM proline was added to the culture medium.

There were two floral buds in each of the test tubes which were incubated at 32°/26° or 26°/20°C (day/night) with 900 lux from 3:00 a.m to 6:00 p.m. for 6, 4, and 2 days at 6 DBA, 4 DBA, and 2 DBA, respectively. Each treatment had three replicates (i.e., high temperature, high temperature + proline, and optimal temperature), and each replicate had eight test tubes. They were examined for anthesis, bud browning, pollen stainability, and pollen germination. After different periods of culturing, pollen staining was conducted with aceto-carmine dye. At the same time, pollen germination was determined after 4 hr of incubation in 20% sucrose and 100 ppm H_3BO_3 at 27°C.

Results

There was high bud-browning at 6 DBA and 4 DBA, especially at high temperature incubation (Table 8). This result suggests that these stages might be the most critical to high temperature. Addition of proline to CL5915 floral buds at 6 DBA and 4 DBA reduced browning at high temperature. Slight browning reduction was also noticed at 4 DBA of L387 buds. This reduction of bud-browning by proline might be due to its heat protectant qualities. Regardless of temperature, L387 at 6 DBA tended to have more bud browning than CL5915. Whether this difference is contributing to heat tolerance in CL5915 deserves further investigation.

There was high bud opening from floral buds at normal temperature. Bud stage also significantly affected bud opening, which was more pronounced in CL5915 at high than at optimal temperature. In general, buds suffered more which were collected at earlier than at the later dates. Furthermore, CL 5915 had more opened buds than L387 at 6 DBA in normal temperature. This signifies that heat-tolerant CL5915 can open its flower even when cultured at an early stage of bud development.

There were no significant differences in the percentages of pollen staining by temperature treatments or bud stages, except in CL5915 which at 2 DBA had higher pollen staining than L387. The staining was generally good regardless of culture stages and temperature. However,

Table 8. Percentage opening, browning, pollen-staining and pollen germination of floral buds cultured under different temperatures[z].

Entries	Optimal Temp.			High Temp.			High Temp. + Pro.		
	6 DBA	4 DBA	2 DBA	6 DBA	4 DBA	2 DBA	6 DBA	4 DBA	2 DBA
Bud browning									
CL5915	b12	12	0	b50a	29a	2b	38a	6b	0b
L387	a52a	12b	0b	a94a	27b	2c	96a	19b	0c
Bud opening									
CL5915	a83	83	91	25b	48b	92a	42b	54ab	83a
L387	b58b	75ab	92a	50	65	85	46b	67ab	83a
Pollen staining									
CL5915	69	82	68	54	74	a71	73	69	69
L387	57	67	70	75	68	b53	64	57	61
Pollen germination									
CL5915	a2b	8ab	b14a	0	0	0	0	0	0
L387	b0b	8b	a34a	1	0	0	0	0	0

[z]Letters to the right of numbers: mean separation within columns by Duncan's Multiple Range Test, 5% level, letters to the left: mean separation within rows of the same treatment by DMRT, 5% level.

in a related experiment without culturing, there was no pollen-staining on pollens obtained from 6 DBA. Pollen-staining percentages of fresh and cultured floral buds at 4 and 2 DBA were comparable.

Pollen germination of both entries was significantly higher at optimal temperature than at high temperature with or without proline. Floral buds collected at 6 and 4 DBA had significantly less pollen germination than those at 2 DBA at optimal temperature. At optimal temperature, no germination occurred on L387 pollens at 6 DBA. In a related experiment without culturing, the pollens of fresh buds did not germinate, too, and pollens at 6 DBA were clearly still immature.

Although the aceto-carmine technique has been suggested as a quick method of assessing pollen viability, our results did not show any correspondence between pollen-staining and pollen germination. The staining technique may be used to determine pollen maturity, but should be tested further for a more reliable evaluation of pollen viability.

Conclusion

Satisfactory results were obtained with the culture of tomato floral buds at 6, 4, and 2 DBA with a modified MS medium. High temperature affected the buds and reduced pollen germination. The younger floral buds (6 and 4 DBA) had less bud opening and more browning. In general, however, opening was at a satisfactory level and browning was not too high. The addition of proline to the medium slightly reduced browning. Pollen staining was high, in general, and did not show any differences among treatments. Pollen germination, in general, was low and present only at optimal temperature. CL5915 had more pollen germination, more bud-opening, more pollen-staining, but less browning than L387.

In vitro floral bud culture may be a tool to facilitate physiological studies of gametogenesis. However, further studies need to be conducted on normal gametogenesis of young floral buds under *in vitro* conditions. The precise modification of media should also be done for long-term experiment, such as fruit-setting, ovary development, and seed-setting.

Evaluation of Morphological and Physiological Characters of Heat-Tolerant Tomatoes in a Multiple-Season Trial

Introduction

The interrelationship between tomato and a high temperature environment, and the relationship between relevant physiological processes and the genetic variation of these processes are complex. In order to enhance the level of heat tolerance, it is necessary to search for aspects of growth and development which are relevant to successful fruit set at high temperature. A reasonable approach would to be to make an inventory of genotypes for a wide series of separate, but basic physiological capacities related to fruit set at high temperature, in order to obtain a better understanding of the genotype values. This inventory could be followed by breeders for a recombination of complementary traits. The present experiment utilized materials which had been previously identified as heat-tolerant, and characterized some physiological processes relevant to heat tolerance of tomato.

Materials and Methods

Seedlings of twenty accessions and seven AVRDC improved breeding lines were field-planted on March 8, April 9, May 9, June 15, July 11, and August 24, 1984. A randomized complete block (RCB) design was employed with four replicates of 20 plants/replicate. All plants were maintained as double stems with staking, but without pruning. Plants from each replicate were randomly selected and tagged for physiological observations.

Cluster 2 to 6 were used for investigating fruit set, fruit number, fruit weight, and seed number. Flowers at anthesis of nontagged plants of each replicate were collected and examined for stigma exsertion and antheral cone splitting before separating anthers and pistils and measuring their heat injury at 50°C. In the meantime, the third expanded leaves from the top were also sampled and measured for specific leaf weight (SLW) and heat injury at 50°C. Heat injury was measured according to the method described earlier.

Results

The May planting was destroyed by a virus outbreak and is therefore not discussed here. Mean maximum and minimum temperatures and total precipitations were high in plantings of April, June, July, and August, and resulted in low fruit yield, less fruit number, small fruit size, and less fruit set (Table 9). On the other hand, plantings in June and July resulted in either high antheral cone splitting or high stigma exsertion. This supports previous findings that both antheral cone splitting and stigma exsertion could be promoted by high temperature.

There was less heat injury to pistils from plants grown in hot months. This is probably due to the gradual adaptation of pistils under sublethal high temperature in April, June, July, and August plantings. Heat injury to pistils was higher than those to anthers and leaves, suggesting that pistils are very susceptible to high temperature. No consistent pattern of changes in SLW, anther and leaf injury was noticed during different months of planting.

During the hot, wet months of June, July, and August, both CL5915-153 and L3958 (Saladette) consistently outyielded other entries (Table 10). All high-yielding AVRDC-breeding lines had large numbers of medium-sized fruits. L3958 had few fruits; however, its fruit size was, in general, much larger than those of all other entries including AVRDC's high-yielding breeding lines (Tables 10 and 11).

It is interesting to note that large-fruited entries had also high SLW (Table 11). Significant positive correlations of fruit size and SLW were found for all three plantings ($r = 0.539^{**}$, 0.533^{**} and 0.632^{***} for June, July and August plantings, respectively). High-yielding L3958 had high values of SLW in these three plantings. Since SLW is defined as the ratio of leaf dry weight per unit leaf area, our results indicate the important source factor of net photosynthesis for fruit size; possibly enhancing dry-matter accumulation in the fruit. Our previous work on mungbean indicated a strong correlation of SLW and net photosynthesis. Thus, it is possible to improve net photosynthesis for large fruit size in tomato through selection of easily measured SLW.

Table 9. Total rainfall (mm) and mean values of temperature (°C), fruit yields, yield components, and morphological and physiological parameters of 27 field-grown tomatoes.

Parameter	Field Planting[z]				
	March	April	June	July	Aug.
Mean max/min temp	27.3/18.5	28.4/21.0	31.7/25.5	31.2/24.3	31.6/23.1
Precipitation	146	576	464	615	323
Fruit yield (g/plant)	557a	280b	78c	48d	81c
Fruit no. (g/plant)	22a	14b	5c	3d	5c
Fruit wt (g/fruit)	31a	21b	16c	14c	19b
Seed no. (g/fruit)	96a	64b	31d	26e	42c
Fruit set (%)	64a	46b	17c	12d	19c
Antheral cone split (%)	8b	4c	8b	12a	3c
Stigma exsert (%)	9b	5d	18a	18a	7c
Anther injury (%)	33a	25b	26b	35a	22c
Pistil injury (%)	64a	40d	54b	51c	41d
SLW	3.34c	4.47a	3.35c	3.66b	3.30c
Leaf injury (%)	17a	13b	19a	14b	17a

[z]Mean separation within rows by Duncan's Multiple Range Test, 5% level.

At 50°C, researchers have reported leaf heat-tolerance of Saladette (L 3958). However, our results showed that leaf heat injury of Saladette (L 3958) at 50°C was much higher than that of other entries (Table 12), indicating that its leaves are susceptible to high temperature. The high-yielding, heat-tolerant CL5915-153 also had a high level of leaf heat injury at 50°C. Two intermediate heat-tolerant entries, L3690 (in fruit set) and CL1131-43 (in fruit yield), had least leaf heat injury (Table 12). Our results suggest that leaf heat-tolerance may not be necessarily reflected in fruit set and fruit yield, but that it may be important to look at heat injury of reproductive organs, where fruit setting is taking place.

In terms of fruit setting during the hot, wet months of June, July, and August, CL5915-153, CL1131-65, and CL1131-26 consistently had higher fruit set rates than other entries (Table 12). These entries also had the lowest antheral cone splitting and stigma exsertion (Table 13). Although L3690 (PT365914) tended to have high fruit set, its fruit size was one of the smallest which also resulted in low fruit yield. It is interesting to note that L3690 also had the highest stigma exsertion rates in all three plantings. These results support our previous finding that fruit set at high temperature is not limited by a single factor, such as stigma exsertion.

Pistils were generally more susceptible to heat injury at 50°C than anthers (Table 14). However, no clear correlation of genotypic variation could be found between heat injury of pistils at 50°C and fruit set or fruit yield. However, heat tolerant CL5915-153, CL1131-43, CL1131-26, and L3958 all had the least heat injury of anthers at 50°. These results support our previous finding that heat-tolerant tomatoes had a low leakage of anther electrolytes, indicating a rather stable anther membrane at high temperatures.

Table 10. Fruit yield (g/plant) and fruit number (/plant) of tomatoes in hot, wet months.

Entry[z]	Fruit Yield[y]			Fruit No.[y]		
	June	July	Aug.	June	July	Aug.
6	50d-f	18e-g	148b-d	1.2h-l	0.6e-f	2.7e-j
18	20f	56d-g	20f	1.2i-l	3.3b-f	0.7ij
123	16f	4g	14f	0.7j-l	0.2f	0.9h-j
124	2f	3g	41f	0.1l	0.2f	0.8ij
125	55d-f	20e-g	92d-f	3.8e-i	1.5d-f	4.4d-j
142	18f	3g	23f	4.2d-i	0.8ef	5.0d-j
229	98c-e	72c-g	69d-f	7.0b-d	5.9bc	5.7d-g
232	44ef	18e-g	89d-f	3.7e-j	1.7d-f	5.8d-g
387	0f	4g	16f	0l	0.2f	0.5j
476	8f	2g	3a	3.2f-k	0.8ef	1.2g-j
492	31f	31d-g	58ef	4.2d-i	4.2b-f	7.2de
1076	26f	5g	4f	6.5b-e	1.4d-f	0.7ij
1486	56d-f	18e-g	19f	8.2bc	2.9b-f	2.7e-j
1834	154bc	63d-g	80d-f	8.3bc	3.8b-f	5.2d-i
2985	6f	5g	30f	0.3kl	0.2f	1.1h-j
2991	19f	15g	56ef	2.9f-l	1.7d-f	6.5d-i
3690	18f	3g	24f	13.4a	2.8c-f	18.3a
3957	102c-e	60d-g	52ef	8.4bc	5.5bc	4.6d-j
3958	201ab	135bc	184a-c	6.0cf	3.1b-f	4.8d-j
3982	17f	26d-g	134c-e	1.4g-l	1.6d-f	5.3d-i
1131-26	225a	86c-e	133c-e	13.2a	6.5b	7.7cd
1131-43	164b	90cd	149b-d	8.8bc	4.8b-d	7.7cd
1131-65	196ab	172ab	246a	9.2b	9.9a	12.5b
5915-93	166b	85c-f	220ab	4.3d-h	2.3c-f	5.5d-h
5915-153	204ab	214a	202a-c	9.5b	10.8a	11.4bc
5915-222	99c-e	16f-g	16f	4.5d-g	1.0d-f	0.8ij
5915-229	107cd	70c-g	65d-f	3.0f-l	3.0b-f	2.6f-j

[z]CL1131-F$_{1}$-26-1-0 (1131-26), CL1131-43-8-1 (1131-43), CL1131-65-13-0-1 (1131-65), CL5915-93D$_{4}$-1-0 (5915-93), CL5915-153D$_{4}$-3-3 (5915-153), CL5915-222D$_{4}$-0-3 (5915-222), CL5915-229D$_{4}$-1-3 (5915-229).
Mean separation within columns by Duncan's Multiple Range Test, 5% level.

Table 11. Fruit size (g/fruit) and specific leaf weight (SLW) of tomatoes in hot, wet months.

Entry[z]	Fruit Size[y]			SLW[y]		
	June	July	Aug	June	July	Aug.
6	46a	24bc	54a	4.01a	5.08a	3.72a-d
18	18bc	12bc	29c-e	3.40a-o	3.82c-e	3.48b-f
123	18b-d	15bc	18d-h	3.50a-h	3.96cd	3.10e-f
124	7c-g	4c	45ab	3.50a-g	3.93cd	3.45b-f
125	14b-f	9bc	21d-g	3.44a-k	3.94cd	3.66a-e
142	4d-g	3c	5hi	3.27c-q	3.74c-f	2.76g-i
229	14b-f	12bc	12i-i	3.42a-l	3.81c-f	3.48b-f
232	12b-g	9bc	16e-i	3.09d-w	4.19bc	3.39b-f
387	0g	13bc	31b-f	3.49a-i	3.77c-f	3.45b-g
476	2fg	1c	2i	2.77n-w	2.98gh	2.50i
492	8c-g	8bc	9g-i	3.22c-t	3.48c-h	3.15d-h
1076	4e-g	3c	5hi	3.17d-v	3.10f-h	2.76g-i
1488	7c-g	6c	7g-i	2.78l-w	3.12e-h	2.92f-i
1834	19bc	17bc	15e-i	3.74a-d	3.56c-g	3.37b-f
2985	9b-g	16bc	32b-d	3.82a-e	3.83c-e	3.78a-e
2991	7c-g	6c	9g-i	3.28c-p	3.10f-h	3.07e-i
3690	1fg	1c	1i	2.50w	2.84h	2.77g-i
3957	12b-g	11bc	11f-i	3.48a-j	3.80c-f	3.87ab
3958	35a	62a	39bc	3.96ab	4.62ab	4.07a
3982	13b-g	18bc	26c-f	3.27c-r	3.56c-g	3.58a-e
1131-26	17b-e	10bc	17d-i	3.60a-e	3.54c-h	3.05e-i
1131-43	19bc	14bc	20d-h	3.17c-u	3.13e-h	2.98f-i
1131-65	21b	17bc	19d-h	3.11d-w	3.29d-h	2.72hi
5915-93	40a	33b	40bc	3.24c-s	3.47c-h	3.14d-h
5915-153	22b	20bc	20d-h	3.42a-m	3.97cd	3.30b-h
5915-222	23b	16bc	19d-h	3.40a-n	3.52c-h	3.18c-h
5915-229	37a	25bc	26cf	3.51a-f	3.54c-h	3.45b-f

For footnotes see Table 10

Table 12. Fruit set (%) and leaf heat injury at 50°C (%) of tomatoes in hot, wet months.

Entry[z]	Fruit Set[y]			Leaf Heat Inury[y]		
	June	July	Aug.	June	July	Aug.
6	8m-s	4hi	13e-h	13e-o	13e-k	13f-i
18	7n-s	5g-i	5gh	18c-j	15c-h	13f-i
123	3q-s	2i	3gh	22b-d	14c-i	19c-f
124	0s	0i	3h	18d-l	15c-h	18d-h
125	14h-o	7f-i	18d-h	10o	11g-k	16d-i
142	14i-p	5g-i	25b-e	13e-o	12f-k	16d-i
229	23f-h	16c-f	19d-h	26a-c	30a	28a
232	11l-q	6g-i	25b-e	8o	7i-k	19c-g
387	1s	1i	5gh	18d-n	15c-h	18d-h
476	11l-r	4hi	8f-n	18c-k	19b-d	25a-c
492	21f-j	22b-d	35bc	18d-m	11g-k	27ab
1076	22f-i	9f-i	6gh	20b-f	12f-k	21b-e
1488	26d-g	12e-h	17d-h	10m-o	11g-k	22a-d
1834	36bc	24bc	27b-e	19b-h	18c-f	21b-e
2985	1s	1i	5gh	32a	19b-e	27a
2991	9m-s	5g-i	23b-f	12h-o	8i-k	12g-i
3690	46a	12e-h	58a	10m-o	6k	11i
3957	19f-l	14d-g	17e-h	26ab	25ab	22a-d
3958	21f-k	20c-e	17d-h	20b-g	13d-j	13f-i
3982	9m-s	9f-i	19c-g	19b-i	9h-k	16d-i
1131-26	33cd	30ab	29b-e	8o	10g-k	14e-i
1131-43	27c-f	16c-f	28b-e	8o	9h-k	11i
1131-65	33c-e	39a	37b	8o	10g-k	17d-i
5915-93	17g-m	10f-i	23b-f	20b-e	7jk	13f-i
5915-153	42ab	35a	33b-d	15d-o	20bc	14f-i
5915-222	4o-s	8f-i	4gh	13e-o	16c-g	15d-i
5915-229	14h-n	14d-g	7gh	13e-o	14c-j	11hi

For footnotes see Table 10

Table 13. Antheral cone splitting (%) and stigma exsertion (%) of tomatoes in hot, wet months.

Entry[z]	Antheral Cone-Splitting[y]			Stigma Exsertion[y]		
	June	July	Aug.	June	July	Aug.
6	24b	29a-c	22a	16i-k	29de	10b-e
18	4de	21b-e	4cd	28d-i	27de	3c-f
123	15b-d	10d-g	0d	12j-l	7gh	0f
124	10b-e	17b-g	3cd	48c	13f-h	11bc
125	7c-e	26b-d	2cd	40cd	23d-f	2d-f
142	4de	7e-g	1d	33d-g	25d-f	2c-f
229	7c-e	12d-g	2cd	0l	0h	2d-f
232	11b-e	6e-g	3cd	39c-f	43c	5c-f
387	18bc	18b-f	9bc	40c-e	35cd	18b
476	4de	10d-g	0d	3k-l	0h	1ef
492	3de	8e-g	1d	33d-h	29de	2d-f
1076	0e	4fg	1d	0l	1h	0f
1488	2de	14c-g	0d	1l	0h	1ef
1834	1de	1g	0d	0l	0h	0f
2985	14b-e	30ab	4cd	24g-j	7gh	1ef
2991	3de	3fg	4cd	1l	0h	1ef
3690	2de	1g	3cd	100a	99a	90a
3957	4de	14b-g	0d	3kl	0h	0f
3958	8c-e	10e-g	2cd	0l	0h	7c-f
3982	43a	43a	13b	14i-l	66b	8c-f
1131-26	3de	3fg	0d	1kl	0h	0f
1131-43	0e	1g	0d	0l	1h	0f
1131-65	3de	1g	0d	4kl	2h	0f
5915-93	6c-e	11d-g	3cd	65b	45c	11b-d
5915-153	3de	2fg	3cd	0l	0h	2d-f
5915-222	4de	13d-g	1d	0l	4h	2d-f
5915-229	4de	15b-g	6cd	1l	18e-g	0f

For footnotes see Table 10.

Conclusion

An inventory of 25 entries which had been previously identified as heat-tolerant tomatoes and two entries of heat-sensitive accessions was made to identify genetic variation in fruit set and fruit yield and their associated morphological characters and physiological processes under hot, wet conditions. The variation for physiological characters could be further evaluated and exploited.

An AVRDC breeding line, CL5915-153D_4-3-3, is the most heat-tolerant entry. It had high fruit-set percentage and the least stigma exsertion, antheral cone splitting, and anther heat injury at 50°C. Fruit yield of accession, L3958 (Saladette), was comparable to that of CL5915-153D_4-3-3, but fruit set percentage and fruit number were generally lower. Its fruit size, however, was generally large. L3958 also had high SLW, which may act as an important source factor for dry-matter accumulation in the fruit. Other AVRDC breeding lines, CL1131-F_5-26-1-0, CL1131-65-13-0-1, and CL5915-93D_4-1-0, also had good fruit yield. CL1131-F_5-26-1-0 and CL1131-65-13-0-1 appeared to have high fruit set percentage and fruit number.

Table 14. Heat injury at 50°C (%) of anthers and pistils of tomatoes in hot, wet months.

Entry[z]	Anther Heat Injury[y]			Pistil Heat Injury[y]		
	June	July	Aug.	June	July	Aug.
6	35b-d	45b	36a	52e-m	42hi	38d-g
18	25f-n	32g-j	37a	41r-z	50e-h	48b-d
123	23k-r	30h-j	28bc	54b-h	58d-f	55b
124	22l-s	28i-k	20f-h	33a	27j	22h
125	15s	26j-m	18g-i	49h-u	41hi	42c-g
142	23k-q	37d-k	19f-i	50f-q	58d-f	48b-e
229	36bc	40b-e	29b	42h-v	42hi	36fg
232	25f-o	32g-j	20f-h	53d-i	57d-g	36g
387	35b-e	29i-k	27b-d	46h-w	34ij	37e-g
476	31c-j	38c-g	22d-h	53d-j	70a-c	55b
492	21m-s	41b-d	28bc	60b-e	67b-d	65a
1076	42a	60a	40a	52f-o	80a	48b-d
1488	31c-g	43b-d	29b	73a	59c-e	47b-f
1834	40ab	44bc	23c-g	58b-g	54e-h	38d-g
2985	31c-i	34e-i	25b-e	53e-l	43hi	36g
2991	28f-k	26i-l	17h-i	49h-t	53e-h	36f-g
3690	19n-s	28i-l	17h-i	61b-d	74ab	55b
3957	31c-h	37c-g	11jk	45j-y	45g-i	35g
3958	21l-s	19m	18g-i	53d-k	46f-i	33g
3982	31c-f	39b-f	21e-h	49h-r	44g-i	36g
1131-26	18o-s	28i-l	14ij	58b-i	51e-h	50bc
1131-43	23k-p	22k-m	11jk	52e-n	44hi	36g
1131-65	22l-s	33f-i	26b-e	62bc	47e-h	41c-g
5915-93	28b-l	31g-j	24b-f	45i-x	45g-i	36g
5915-153	19m-s	22k-m	9k	62b	51e-h	42c-g
5915-222	20m-s	21ml	19f-i	52f-p	50e-h	43c-g
5915-229	25f-m	26i-l	17hi	49h-s	41hi	35g

For footnotes see Table 10

Alternation of Endogenous Plant Hormones of the Tomato Fruit-Setting Process During Hot and Cool Seasons

Introduction

High temperature reduces or limits tomato production in the tropics by inhibiting fruit set. Exogenous applications of auxins and gibberellins are known to overcome this effect. High temperatures are also known to reduce auxin and gibberellin contents in tomato flower buds and auxin content in developing fruit, and to increase abscisic acid in tomato shoots. Little is known, however, about hormonal levels during the initiation of fruit set of both parthenocarpic and nonparthenocarpic heat-tolerant and heat-sensitive tomatoes. In this report a comparison is made of auxin, gibberellin, and abscisic acid levels in the reproductive organs before, at, and after anthesis of parthenocarpic, and nonparthenocarpic heat-tolerant and heat-sensitive tomatoes grown under favorable and unfavorable conditions.

Materials and Methods

CL1131-0-0-43-8-1 (CL1131), TK70, Severianin, and (SxP)-0-4 were sown on May 11 and field-planted on June 13. A randomized complete block (RCB) design with three replications was employed. Flower buds and/or open flowers two days before anthesis (DBA), at anthesis (0 DBA), and three and six days after anthesis (DAA) were sampled in July 18 to 31. Mean maximum and minimum temperatures from field planting to sampling were 33.0° and 24.7°C, respectively. In a similar experiment for cool season, PT1013, CL1131-0-0-43, and TK70 were sown on September 20 and field-planted on October 17. Reproductive organs at different stages as in the previous investigation were sampled in December 1 to 11. Mean maximum and minimum temperatures from field planting to sampling were 27.9° and 18.1°C, respectively.

The number of reproductive organs from different stages were counted, and their calyxes and anthers were removed to leave only the pistils which were weighted and extracted twice with cold methanol in a cold room. Methanol was removed *in vacuo* at 35°C and the remaining aqueous was adjusted to pH 8.0 by adding 0.5 M phosphate buffer. This was then purified with PVP and washed three times with phosphate buffer. The pH of the aqueous solution was adjusted to pH 2.5 with 6 N HCl, and the solution partitioned three times with equal amount of ethyl acetate.

This acidic fraction was purified again with TLC with silical gel and solvent system of chloroform: ethyl acetate: acetic acid (60:40:5). This was later eluted with methanol: ethyl acetate (1:1) mixture, and evaporated to dryness. Quantifications of indole-3-acetic acid (IAA), gibberellic acid (GA_3), and abscisic acid (ABA) were conducted by the Waters Associate HPLC Model 440 absorbance detector with a Waters micro-Bandapak C18 column. Mobile phase was methanol:H_2O:acetic acid (45:55:1.2); the flow rate was 1.2 ml/min.; and detection was conducted at 254 nm.

Results

In the summer crop, the ovary growth of all entries increased up to anthesis. The ovary growth of CL1131-0-0-43 and TK70 was arrested after anthesis, but that of parthenocarpic Severianin and SxP-0-4 kept going rapidly between 3 and 6 DAA (Table 15). This trend resulted in better fruit setting in Severianin and SxP-0-4.

In contrast, the ovary growth of the three cultivars in the fall steadily increased from 2 DBA, and resulted in good fruit set. There was a rapid ovary growth of CL1131-0-0-43 at 3 and 6 DAA of the fall crop. The faster ovary growth rate of Severianin and SxP-0-4 in the summer may be attributed to high summer temperatures.

Except for S × P-0-4 in the summer crop, both flower buds and small, developing ovaries had higher levels of IAA concentration at 3 DAA than at 0 DBA, which decreased with

Table 15. Ovary growth, fruit set, and seed number of tomatoes grown in summer and fall.

Planting Entry	Ovary Growth (mg fresh wt/ovary)				Fruit Set[z] %	Seed No./ Fruit
	2 DBA	0 DBA	3 DAA	6 DAA		
Summer Planting						
Severianin	4.4	8.6	16.9	189.0	14.6a	0
SxP-0-4	3.2	6.8	10.6	188.0	4.1b	0
CL1131	1.8	4.1	5.0	6.2	1.3b	--
TK70	3.5	7.9	9.3	9.1	0	-
Fall Planting						
PT1013	12.0	14.0	19.0	26.0	64.0b	39.5c
CL1131	3.3	4.5	6.3	35.0	92.8a	94.7b
TK70	6.4	8.7	10.0	18.0	63.4b	122.5a

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

increasing age at 6 DAA (Table 16). IAA concentration also tended to decrease from 2 DBA to 0 DBA. This trend was more pronounced in the summer than in the fall crop. The apparent increase in total IAA per ovary did not occur until 3 DAA. At 6 DAA, Severianin and S × P-0-4 with good fruit-setting had high total IAA. In general, IAA concentrations and total IAA per ovary were higher in the fall than in the summer. The difference in total IAA contents between the summer and fall tomato was four-or five-fold at their peaks.

The GA_3 concentration and the total GA_3 per ovary in all entries were generally higher in the fall than in the summer (Table 17). The GA_3 concentrations peaked at 3 DAA in summer but rapidly decreased at 6 DAA. A great drop in GA_3 concentration from 2 DBA to 0 DBA was found in two no-fruit-setting entries (TK70 and CL1131-0-0-43). There was little or no drop in Severianin and S × P-0-4. In the fall tomato, a little or no drop of GA_3 concentration was noticed at 0 DBA. The results suggest that GA_3 may hold the key to the control of fruit set at high temperature.

At 0 DBA in the summer crop, both Severianin and S × P-0-4 had high total GA_3 content per ovary which rapidly increased through 3 DAA to 6 DAA. TK70 increased at 0 DAA but decreased thereafter. In the fall, there was a gradual increase of total GA_3 per ovary from 2 DBA to 6 DAA without any clear reduction. The increase of total GA_3 per ovary in fall over summer tomato was about 3-to 54-fold at their peaks.

Table 16. Changes in extractable IAA (μg/g fresh wt or ng/ovary) in the developing tomato ovary.

Stage	Severianin		S × P-0-4		CL1131		TK70	
	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Summer Planting								
2 DBA	0.41	1.7	0.16	0.5	0.26	0.5	0.16	0.5
0 DBA	0.03	0.25	0.04	0.2	0.06	0.2	0.07	0.5
3 DAA	0.23	3.0	0.01	0.1	0.22	1.2	2.19	19.1
6 DAA	0.07	130.6	0.08	66.8	0.05	7.2	0.28	1.6
			PT1013		CL1131		TK70	
			fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Fall Planting								
2 DBA			0.58	6.8	0.84	2.8	0.42	2.7
0 DBA			0.26	3.5	0.39	1.8	0.20	1.8
3 DAA			0.36	7.0	0.37	4.3	0.31	3.2
6 DAA			0.39	9.9	0.19	6.5	0.77	13.6

Table 17. Changes of extractable GA_3 (μg/g fresh wt or ng/ovary) in the developing tomato ovary.

Stage	Severianin		S × P-0-4		CL1131		TK70	
	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Summer Planting								
2 DBA	0.89	3.8	0.43	1.4	0.90	1.6	1.35	4.7
0 DBA	0.74	6.4	0.63	4.0	0.24	1.0	0.26	2.0
3 DAA	3.81	52.5	1.19	30.6	1.34	7.0	4.24	37.6
6 DAA	0.06	111.7	0.29	256.0	0.46	70.0	0.69	6.2
			PT1013		CL1131		TK70	
			fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Fall Planting								
2 DBA			8.9	103.3	13.7	44.3	9.4	59.8
0 DBA			12.1	165.0	13.6	61.4	7.2	62.5
3 DAA			10.5	202.0	19.5	123.3	11.7	122.2
6 DAA			12.3	318.0	16.1	506.8	18.5	323.6

In all entries, the extractable ABA's were markedly higher in summer than in fall (Table 18). ABA concentration decreased from 2 DBA to 0 DBA for both plantings. However, it increased rapidly for CL1131-0-0-43 and TK70 in summer after 0 DBA.

Although in full it increased ABA in PT1013 and TK70 after anthesis, this increase was not as great as in the summer tomato. In general, total ABA per ovary increased after anthesis for summer and fall tomato, but at a much lower rate in fall with a difference of 17-to 95-fold at their peaks.

Conclusion

The results support the assumption that temperature plays an important role in controlling levels of endogenous plant hormones in tomato. Whether fruit set is the result of these changes or whether they are merely a consequence of arrested ovary growth can not be answered conclusively in this study. An obvious relationship between fruit set or early ovary growth and the changes in hormone levels in the tomato ovary under favorable and unfavorable environmental conditions is also indicated.

The results clearly show that high levels of extractable IAA and GA_3 and low levels of extractable ABA are usually associated with pistils of plants grown under favorable conditions for fruit-setting. It can also be inferred that IAA and GA_3 play an important role at anthesis. Both hormones may operate by preventing the abscission of the developing ovaries promoted by a high ABA concentration and by stimulating vascular development.

It is suggested that a threshold concentration of endogenous IAA is necessary for parthenocarpic fruit development and that the level of GA_3 may hold the key to controlling fruit set at high temperature.

Table 18. Changes of extractable ABA (μg/g fresh wt or ng/ovary) in the developing tomato ovary.

Stage	Severianin		S x P-0-4		CL1131		TK70	
	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Summer Planting								
2 DBA	4.76	20.4	3.92	12.9	3.74	6.6	2.21	7.8
0 DBA	0.61	5.3	0.67	4.3	0.47	1.9	0.12	1.0
3 DAA	2.41	32.4	0	0	1.31	7.1	9.75	87.4
6 DAA	0.88	1627.2	2.47	2205.7	7.05	1067.7	1.18	10.7
			PT1013		CL1131		TK70	
			fr. wt	ovary	fr. wt	ovary	fr. wt	ovary
Fall Planting								
2 DBA			0.71	8.4	0.55	1.8	0.56	3.6
0 DBA			0.35	4.8	0.37	1.7	0.32	2.8
3 DAA			0.53	10.12	0.37	2.3	0.49	5.1
6 DAA			0.32	8.2	0.32	11.2	0.38	6.8

Effect of Pollination on Fruit Set of Parthenocarpic and Seeded Tomatoes in Summer

Introduction

Parthenocarpic tomatoes usually set seedless fruits under adverse hot environmental conditions, but form normal, seeded fruits under favorable cool environmental conditions. Why the several physiological processes of pollination and fertilization are bypassed under adverse hot environmental conditions is not clear. The often used explanation is that the reproductive organs of parthenocarpic tomatoes maintain high levels of endogenous plant

hormones, such as auxins and gibberellins. However, the role of plant hormones in parthenocarpic fruit formation is still uncertain. The present experiment investigated the effect of pollination on the fruit set of parthenocarpic and seeded tomatoes under high temperature conditions.

Materials and Methods

CL1561-6-0-5-1-3 was field-planted on March 1, 1984. Pollens of this entry was continuously collected from April 18, stored in a -15°C freezer, and used as a pollen source for later pollination studies. On the other set of planting, seedlings of CL1131-0-0-43-8-1, BL6807 (L3957), TK70 (L124), PT1416 (Ventura × CL1131-38), and Severianin were field-planted on May 15, 1984. A randomized complete block (RCB) design with four replications was employed in the field.

Flower buds were tagged one day before anthesis for 1) emasculation without artificial pollination, 2) emasculation with artificial pollination of pollens from CL1561-6-0-5-1-3, and 3) natural pollination without emasculation or artificial pollination. For each treatment, 20 flower buds per treatment were randomly selected and tagged from 36 plants of each replicate. Artificial pollinations were conducted on June 14 and 22, 1984. Four hours after pollination, two flowers of each replicate were sampled and observed under a fluorescent microscope for pollens stuck on the stigma. Visual ratings of 1 (no pollen), 2 (some pollens), and 3 (many pollens) were used. Fruit set rate and other morphological characteristics were observed on July 13 and 19. Mean maximum and minimum temperature (°C) from field planting to sampling were 31.0 (22.8 to 34.2) and 23.8 (20.0 to 26.0), respectively.

Results

Fruit set percentage after emasculation with or without artificial pollination on June 14 or natural pollination is shown in Table 19. CL1131-0-0-43, BL6807, and Severianin showed higher fruit set percentage than other two entries under natural pollination conditions. Emasculation without artificial pollination reduced the fruit set of CL1131-0-0-43 and BL6807, and Severianin. The results implied that both CL1131-0-0-43 and BL6807 were able to produce viable pollens under high temperature condition, and to pollinate and set fruits by themselves. On the other hand, emasculation with artificial pollination substantially improved the fruit set of CL1131-0-0-43 and BL6807. It also improved that of PT1416 and TK70, but not CL1131-0-0-43 and BL6807. It was not effective, however, on Severianin under high temperature conditions.

Artificial pollination with viable pollens circumvented the barrier of stigma exsertion and antheral cone splitting which prevented chances of pollination. Since the improved fruit set of PT1416 and TK70 by artificial pollination did not reach the level of CL1131-0-0-43 and BL6807, it suggested that ovules and/or pistils of PT1416 and TK70 might be partially damaged by high temperature.

Table 19. Floral characteristics and fruit set of tomatoes with or without emasculation and pollination.

Entry	Stigma Exsertion[z] (%)	Antheral Cone Split[z] (%)	Fruit Set (%)[z]		
			nat. pollin.	emasc. without pollin.	emasc. with pollin.
CL1131	3.3c	3.4b	b14.8ab	c0	a39.3a
PT1416	40.0b	86.6a	b3.9bc	b4.0	a22.4b
BC6807	3.3c	14.1b	b18.7a	c4.2	a52.9a
Severianin	0.3c	4.6b	14.8ab	7.2	4.9c
TK70	73.3a	2.0b	b0.6c	b0	a18.3bc

[z]Letters to the right: mean separation within columns by Duncan's Multiple Range Test, 5% level; letters to the left: mean separation within rows of fruit set by DMRT, 5% level.

On the other hand, antheral cone splitting and stigma exsertion were low in BL6807 and CL1131-0-0-43; therefore, their improvement on fruit set by artificial pollination may be purely due to availability of more viable pollens. There were many pollens on the stigma after artificial pollination (Table 20). The noneffective artificial pollination in Severianin, however, suggested that its ovaries might have started to grow before pollination.

Within entries, fruit sizes among treatments did not differ. No seeds were found in fruits promoted by emasculation without pollination. However, seed number was substantially increased by emasculation with pollination on PT1416 but did not alter between natural pollination and emasculation with pollination on the rest of the entries (Table 20). Artificial pollination did not increase seed number on Severianin.

Conclusion

Although high temperature damaged the reproductive processes of tomato, pollination with viable pollens partially overcame this problem for heat-tolerant varieties. Severianin possessed certain levels of heat tolerance with parthenocarpic fruit formation. Pollination with viable pollens did not bring about enhancement of fruit set and seed formation in Severianin. The results suggest that ovules and/or pistils of Severianin may be damaged by high temperature; or that the spontaneous fruit set ability under high temperature may be so overriding that pollination with viable pollens is not effective. These aspects require further investigation.

Table 20. Seed number per fruit and pollen rating on the stigma of tomatoes with or without emasculation and pollination[z].

Entry	Natural Pollination[y]		Emasculation without Pollination[y]		Emasculation with Pollination[y]	
	Pollen	Seed No.	Pollen	Seed No.	Pollen	Seed No.
CL1131	2.0	20.4a	1.0	–	1.8b	16.0a
PT1416	b1.2	b0d	b1.0	b0	a2.2ab	a15.1a
BL6807	b1.5	a8.8c	b1.0	b0	a2.8a	a11.3a
Severianin	ab1.3	0d	b1.0	0	a1.8b	3.8b
TK70	b1.5	15.0b	b1.0	–	a2.5ab	13.5a

[z]Pollen ratings ranged from 1 (no pollen), 2 (some pollens), and 3 (many pollens). [y]Letters to the right: mean separation within columns by Duncan's Multiple Range Test, 5% level; to the left: mean separation within rows of pollen rating on the stigma, or seed number by DMRT, 5% level.

Heat Tolerance of Parthenocarpic and Seeded Tomatoes in Hot Greenhouse Conditions

Introduction

Seeded fruit set involves viable gamete production, and successful pollination and fertilization. High temperature reduces fruit set because parts or all of these processes are damaged. On the other hand, parthenocarpy circumvents these processes to set fruits. Since environment-dependent genetic parthenocarpy exists in tomato, the improvement for heat tolerance in tomato could be expedited substantially if parthenocarpy can be incorporated into seeded tomatoes. The present study investigated the level of heat tolerance in parthenocarpic tomatoes as compared with non-parthenocarpic heat-tolerant and heat-sensitive tomatoes.

Materials and Methods

Fifteen entries of parthenocarpic, and nonparthenocarpic heat-tolerant and heat-sensitive tomatoes were sown and transplanted to 17-cm ID clay pots on June 26, and July 17, 1984,

respectively (Table 21). A randomized complete block (RCB) design with four replications was employed; each replicate had eight pots with one plant per pot. Plants were staked, pruned and maintained as double stems with five clusters of flowers. They were grown in than the greenhouse with mean maximum and minimum temperatures (°C) of 34.9+2.1 (33.3-38.5) and 24.3+2.0 (22.0-26.6), respectively. Four clusters, second to the fifth, were observed for stigma exsertion, antheral cone splitting, fruit set, fruit number, fruit size, and seed number per fruit. At the final investigation, four plants from each replicate were cut at the soil surface level and determined for dry weight.

Results

CL5915-16D_4-7BW-4, CL5915-153D_4-3-3-0, and CL5915-206D_4-2-5 produced higher yields than the rest of the entries (Table 21). This is mainly due to the large number of intermediate-sized fruits produced by these entries. Fruit yield of parthenocarpic tomato was generally low. Both PT1441 and PT 1461 had the highest average fruit sizes, which compensated for low fruit set.

It has been suggested that fruit size depends upon seed number. However, our results indicate this may not be so under high temperature conditions because there was no clear relationship between seed number and fruit size. Although high yielding CL5915-153D_4-3-3-0, CL1131-0-0-43-8-1, and CL5915-16D_4-7BW-5 produced high shoot dry weight, no clear correlation between fruit yield and shoot dry weight was found. This suggests that the key factors determining fruit yield at high temperatures hinge on reproductive growth rather than on dry-matter production or competition between reproductive and vegetative growth.

Among seeded tomatoes, CL5915-153D_4-3-3-0 showed the highest fruit set percentage, and L124 and L387, the lowest. Among parthenocarpic tomatoes, PT1417 and PT1461 had comparable fruit set with seeded, intermediate-seeded heat-tolerant entries, but a higher fruit set than heat-sensitive L124 and L387. Both seeded CL5915-153D_4-3-3-0 and CL1131-0-0-43-8-1 had the lowest rates of stigma exsertion; whereas heat-sensitive L127, L387, and CL5915-39D_4-1-5 had highest rates. There was a negative correlation between stigma exsertion and fruit set ($r = -0.538^{**}$).

Table 21. Fruit and plant characteristics of 15 parthenocarpic and seeded tomatoes grown at high temperatures.[z]

Entries[y]	Fruit Set (%)	Fruit Wt (g/plant)	Fruit Size (g/fruit)	Seed No. /fruit	Stigma Exsert. (%)	Shoot Dry Wt (g/plant)
L124	3f	11e	10c	7c	95a	19b-d
L387	3f	12e	18cb	20b	96a	20b-d
Severianin	6f	29de	30b	1d	8f	25ab
PT1417	18c	62c-e	17bc	0d	41cd	19b-d
PT1441	7ef	59c-e	53a	0d	53bc	21a-d
PT1453	6ef	26e	20bc	4cd	32dc	23a-c
PT1461	12de	83b-d	61a	2cd	53bc	19b-d
PT1541	3f	12e	16a	5cd	16ef	19b-d
43-8-1	28b	92a-c	15bc	19b	4f	28a
16D_4-7BW-4	32b	136ab	22bc	6cb	31de	16cd
16D_4-7BW-5	19c	98a-c	21bc	6cd	24e	23a-c
39D_4-1-4	14cd	84bc	27bc	20b	64b	20b-d
39D_4-1-5	8ef	49c-e	23bc	25a	86a	19b-d
153D_4-3-3-0	42a	143a	17bc	16b	2f	23a-c
206D_4-2-5	18c	139a	24bc	9c	42cd	14d

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level. [y]CL1131-0-0-(43-8-1), CL5915-(16D_4-7BW-4), CL5915-(16D_4-7BW-5), CL5915-(39D_4-1-4), CL5915-(39D_4-2-5), CL5915-(153D_4-3-3-0), CL5915-(206D_4-2-5)

In general, fruit set decreased with the increasing order of cluster position, regardless of whether the entries were seeded or parthenocarpic (Table 22). Conversely, stigma exsertion increased with the increasing order of cluster position, except CL5915-16D_4-7BW-4 which had a high fruit set at a high order of cluster position, even when its stigma was highly exsertile. High fruit-setting CL5915-153D_4-3-3-0 and CL1131-0-0-43-8-1 had no antheral cone splitting, whereas many of the intermediate heat-tolerant CL lines and heat-sensitive L124 had low antheral cone splitting. Parthenocarpic tomatoes tended to have a high antheral cone-splitting rate.

Conclusion

In general, fruit yield and fruit set of parthenocarpic tomatoes were less than the seeded, heat-tolerant tomatoes. However, parthenocarpic PT 1461 showed comparable fruit set and yield with those of seeded, intermediate heat-tolerant tomatoes. This finding suggests that it possesses natural heat-tolerance to some extent. Fruit sizes of parthenocarpic PT1441, PT1461, and Severianin were generally larger than those of other entries, which partially compensated for their low fruit set. This study confirms the findings that the improved and seeded, heat-tolerant tomatoes of AVRDC have higher yield and fruit-set rates than parthenocarpic tomatoes at high temperatures.

Table 22. Fruit set (%), stigma exsertion (%), and fruit weight (g/cluster) of 15 parthenocarpic and seeded tomatoes as affected by cluster position.

Entry[z]	Fruit Set[y]				Stigma Exsertion[y]				Fruit Wt[y]			
	2nd	3rd	4th	5th	2nd	3rd	4th	5th	2nd	3rd	4th	5th
PT1461	8	13	12	15	26b	69a	52ab	67a	16	23	18	26
43-8-1	50a	27b	20b	16b	0	8	0	7	33	23	20	16
16D_4-7BW-4	41a	15c	30b	44a	12b	10b	53a	48a	30b	12c	31b	62a
153-3-3-0	57a	43b	40b	30c	2	0	7	0	46	35	32	30
206D-2-5	20	21	12	21	30	33	48	56	31	32	29	47
$\bar{X}$ of 15 entries	19a	13b	13b	14b	32b	42ab	48a	50a	19	14	15	20

[z]See Table 21 for entries evaluated. [y]Mean separation within rows of same characters by Duncan's Multiple Range Test, 5% level.

Inheritance in Parthenocarpic and Seeded Tomatoes under Hot Greenhouse Conditions

Introduction

The expression of parthenocarpy usually occurs under high temperature conditions, and it has been found to be simply inherited. It would be interesting to know if this environment-dependent parthenocarpy can be combined with seeded, heat-tolerant tomato to further improve the level of heat tolerance in tomato. This experiment investigated the inheritance of heat-tolerant traits in parthenocarpic and seeded tomatoes under hot greenhouse conditions. Three parental lines which are environment-dependent genetic parthenocarpic, seeded heat-tolerant, and seeded heat-sensitive were investigated for fruit yield and its components, and morphological traits associated with fruit setting.

Materials and Methods

The nine tomato families are as follows:

1. PT1453 [Ventura-1-0 (B)-1] as P_1: facultative parthenocarpy controlled by a single recessive gene.

2. PT1504 (CL1131-0-0-38-4-0-1A) as P_2: seeded heat-tolerant breeding line.
3. PT1064 (UC 82B) as P_3: seeded heat-sensitive line.
4. PT913 (Ventura × CL1131) as F_1 ($P_1 \times P_2$).
5. PT996 (Ventura × UC82B) as F_1 ($P_1 \times P_3$).
6. PT1359 [(Ventura × CL1131)-0] as F_2 [($P_1 \times P_2$)-0].
7. PT0005 [(Ventura × UC82B)-0] as F_2 [($P_1 \times P_3$)-0].
8. PT1419 [Ventura × (Ventura × CL1131)] as BC-P_1.
9. PT1421 [CL1131 × (Ventura × CL1131)] as BC-P_2.

Seedlings were transplanted to clay pots on June 25, 1984 and the pots were placed in the greenhouse. There were 10 plants each for parental line and F_1, and 40 plants each for other families. Plants were investigated at 57 days after transplanting. Each plant of these families was investigated for fruit yield, fruit size, fruit number, seed number, antheral cone splitting, and stigma exsertion during or at the end of the 57-day growing period. During this period, the mean maximum and minimum temperatures (°C) were 36.9 (25.2 to 40.2) and 26.6 (23.7 to 29.0), respectively.

Results

Eight out of nine P_1 (Ventura), three out of 10 P_2 (CL 1131), and five out of eight P_3 (UC82B) plants were seedless. Although P_3 (UC82B) was classified as a seeded, heat-sensitive tomato, it was as completely seedless under extremely high temperatures (Table 23). The chi-test for the segregation of seeded and seedless plants in F_2($P_1 \times P_2$-0), F_2($P_1 \times P_3$-0), BC-P_1 and BC-P_2 did not agree with the single-gene hypothesis. Therefore, it appeared that many genes controlled parthenocarpy and that these genes were recessive, since the F_1 and BC-P_1 and BC-P_2 populations had only few plants which were seedless.

Among the three parental lines, P_2 (CL1131) had the highest fruit yield, fruit set, and fruit number-which made it the most heat-tolerant. P_2 (CL1131) and had comparable stigma exsertion rate but significantly lower antheral cone-splitting rate than P_1 (Ventura). P_3 (UC82B) had low rates of stigma exsertion and antheral cone splitting. Among progeny families, BC-P_2 [CL1131 × (Ventura × CL1131)] had the highest fruit yield, with high fruit set and fruit number percentages, but low antheral cone splitting and stigma exsertion. All of BC-P_2 plants were seeded. Therefore, these results suggest that the heat tolerance level of parthenocarpic tomato does not reach that of seeded tomatoes.

To clarify the relationship between seed formation and fruit yield or its yield components, plants were classified into four types of plants with fruits containing: 1) more than 10 mature seeds, 2) less than 10 mature seeds, 3) immature seeds only, and 4) no seeds. Seedless plants had comparable fruit set and fruit number percentages with those of plants with mature or immature seeds of the same family (Table 24).

Table 23. Average fruit set (%), fruit number (/plant), yield (g/plant), stigma exsertion (%), antheral cone splitting (%) and plant number with seeded or seedless fruits in various tomato families.

Generation	Fruit Yield[z]	Fruit Set[z]	Fruit No.[z]	Stigma Exsert[z]	Cone Split[z]	Plant no.	
						seed	no seed
P_1	46de	25cd	4.3de	41a	24a	1	8
P_2	127b	50a	10.8a	44a	2b	7	3
P_3	15e	18d	2.9e	13b	3b	0	5
F_1($P_1 \times P_2$)	128b	34bc	7.8bc	9b	4b	9	0
F_1($P_1 \times P_3$)	71cd	29cd	5.8b-d	18b	4	6	3
F_2($P_1 \times P_2$-0)	67cd	24cd	5.4b-d	15b	1b	19	11
F_2($P_1 \times P_3$-0)	56de	19cd	4.3de	19b	20a	14	17
BC-P_1	105bc	22cd	5 2c-e	14b	9b	31	2
BC-P_2	187a	44ab	10.2b	8b	0b	38	0

[z]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

However, seedless plants clearly had a smaller fruit size than those containing mature seeds of the same family (Table 25). This resulted in less yield for most of the seedless plants than those with mature seeds. In the same family, plants with more mature seeds tended to have larger fruits than those with less seeds or with immature seeds only. However, because they had more fruits, plants with only immature seeds in F_2 ($P_1 \times P_3$-0) and BC-P_1 had higher yields than those with mature seeds. Whether or not immature seeds enhance fruit yield remains to be investigated further. Our results clearly indicate the importance of seeds whether mature or immature, in controlling fruit size.

Although both P_1 (Ventura) and P_2 (CL1131) had high stigma exsertion percentage, their distributions among the four plant types were quite different (Table 26). P_1 (Ventura) plants with immature seeds had higher stigma exsertion percentage than seedless plants. P_2 (CL 1131) plants with both mature and immature seeds had high stigma exsertion percentage. However, their stigma exsertion percentage was lower in F_1 ($P_1 \times P_2$) and BC-P_2 than in their parents. It seems to indicate that more than one factor controls stigma exsertion.

High antheral cone-splitting percentage was associated with plants having seedless or immature seeds. The controlling antheral cone splitting seemed to be recessive.

Conclusion

Regarding heat tolerance in terms of fruit yield, plants with mature or immature seeds were clearly much better than parthenocarpic plants. Although there was some level of heat tolerance in fruit setting of parthenocarpic tomatoes, its yield could not match those of seeded plants. Seeded plants with mature or immature seeds had larger fruits than those with seedless fruits.

Table 24. Average fruit set and fruit number of four plant types of various tomato families.

Generation	Fruit Set (%)				Fruit No. (no./plant)			
	ripe seeds		unripe seeds	seed-less	ripe seeds		unripe seeds	seed-less
	<10	>10			<10	>10		
P_1	–	9	24	27	–	4	5	4
P_2	44	65	39	–	10	13	9	–
P_3	–	–	–	17	–	–	–	5
$F_1(P_1 \times P_2)$	34	32	–	–	8	7	–	–
$F_1(P_1 \times P_3)$	20	38	35	29	4	8	6	6
$F_2(P_1 \times P_2\text{-}0)$	24	32	12	34	5	7	3	9
$F_2(P_1 \times P_3\text{-}0)$	13	25	30	30	2	6	6	6
BC-P_1	26	27	49	–	6	7	12	–
BC-P_2	45	14	–	–	10	9	–	–

Table 25. Average fruit yield and fruit size of four plant types of various tomato families.

Generation	Fruit Yield (g/plant)				Fruit Size (g/fruit)			
	ripe seeds		unripe seeds	seed-less	ripe seeds		unripe seeds	seed-less
	<10	>10			<10	>10		
P_1	–	40	98	40	–	10	1	9
P_2	178	120	109	–	17	9	12	–
P_3	–	–	–	24	–	–	–	5
$F_1(P_1 \times P_2)$	156	30	–	–	20	4	–	–
$F_1(P_1 \times P_3)$	104	96	46	35	23	12	8	6
$F_2(P_1 \times P_2\text{-}0)$	136	79	22	50	28	11	7	6
$F_2(P_1 \times P_3\text{-}0)$	74	91	136	48	30	16	23	7
BC-P_1	151	114	218	–	25	17	18	–
BC-P_2	186	132	–	–	18	14	–	–

Table 26. Average stigma exsertion and antheral cone splitting of four plant types of various tomato families.

Generation	Stigma Exsert (%)				Antheral Cone Split (%)			
	ripe seeds		unripe seeds	seed-less	ripe seeds		unripe seeds	seed-less
	10	10			10	10		
P_1	–	0	90	40	–	6	80	19
P_2	38	35	55	–	2	3	0	–
P_3	–	–	–	7	–	–	–	2
$F_1(P_1 \times P_2)$	10	7	–	–	3	8	–	–
$F_1(P_1 \times P_3)$	29	5	13	28	0	4	0	0
$F_2(P_1 \times P_2\text{-}0)$	28	11	11	17	0	0	4	1
$F_2(P_1 \times P_3\text{-}0)$	0	7	80	23	0	7	10	26
BC-P_1	4	18	61	–	3	14	28	–
BC-P_2	8	6	–	–	0	0	–	–

Processing Tomato Breeding

Developing Heat-Tolerant and Disease-Resistant Processing Tomatoes

Introduction

Most countries in the tropical region have an insufficient supply of tomatoes and rely on imports for processing. The major reason for this is low yield owing to the lack of adaptable, heat-tolerant, and disease-resistant cultivars. In Taiwan, the production of processing tomato is limited to the cool dry period of December to March. Cultivars which can be grown earlier or later would reduce the production cost in the sense that the processing facilities can be intensively used during the year.

AVRDC initiated a project in 1981 to develop processing tomato cultivars and breeding materials for tropical and subtropical countries. It was funded in part by the Council for Agricultural Planning and Development (CAPD) of Taiwan for three years, from July 1982 to June 1985.

Materials and Methods

The strategy used in this project was to combine the heat and bacterial wilt resistance of the AVRDC tropical tomatoes with the superior processing quality and disease resistance of commercial processing cultivars.

The project has two components. The first was aimed at developing F1 hybrid cultivars with desirable traits in a short time. The second is a long-term project aimed at developing open-pollinated cultivars and improving breeding materials for the hybridization program. These components were conducted together since 1981.

In 1982 and 1983, a total of 190 F1 hybrid combinations were produced and tested; and the elite combinations were selected for preliminary and advance trials in 1983 (Progress Report 1982, 1983). Among them, nine elite hybrids were chosen for the nationwide regional yield trials in Taiwan in 1983 and 1984. These trials were conducted by the Tainan District Agricultural Improvement Station (Tainan DAIS), and the Taiwan Provincial Department of Agriculture and Forestry (PDAF). All entries were evaluated in three different planting dates in late summer, fall, and winter at three locations in major tomato-growing counties of Southern Taiwan. The same materials were also being evaluated in Thailand, Philippines, Malaysia and Korea, beginning 1984 for adaptability tests.

In the late summer of 1984, 20 new F1 combinations were selected for the preliminary yield trial to evaluate yield and heat resistance under hot environments.

A series of seedling inoculation tests were conducted to verify the resistance to root-knot nematode, Fusarium wilt, and ToMV of the F1 and open-pollinated (OP) selections. Inoculation method of the above diseases followed the AVRDC standard seedling inoculation procedure using 24 plants with two replications.

Results

Preliminary yield trials. Table 1 shows the yield and horticultural characteristics of the F1's and the local control cultivars, TK70 and Tainan Selection No.2. Although most plants in this trial were severely infected with cucumber mosaic virus (CMV) and potato virus Y (PVY), some F1 selections seemed to be promising. They produced two to three times more marketable fruits than the control cultivar, TK70.

Most of the entries showing a good level of heat resistance had relatively small fruits, (50 to 55 g). Only two of the moderately heat-resistant selections (TM103 and PT858) had fairly large fruit size. The yields of the first and second pickings indicated the fruit-setting ability under hot periods in the early growing stage. The daily minimum temperature during anthesis of the early clusters was about 23° to 24°C and the mean maximum temperature was 32°C (Fig. 1). PT3025, PT3027, and PT1600 had the best overall rating, with regard to the ability to set fruits under high temperature and fruit characteristics, such as size, firmness, and color.

Three different types of hybrid combinations were included in these trials: 1) introduced cool-season cultivars crossed with AVRDC tropical tomatoes; 2) AVRDC cool-season cultivars crossed with AVRDC tropical tomatoes; and 3) AVRDC new inbreds with some degree of heat tolerance crossed with AVRDC tropical lines.

In general, type 1 crosses had low to medium level of heat resistance, medium to large fruits, and acceptable fruit firmness and color. The second type is similar to type 1, except that it is usually resistant only to ToMV and bacterial wilt (low level). The third type is better than the two in terms of heat and disease resistance.

Table 1. Yield and horticultural characteristics of new F1 processing tomatoes in a preliminary yield trial in the late 1984 summer[2].

PT/No./Variety Name	Yield(t/ha)		Horticultural Characteristics				Overall Rating
	total	early	fruit size (g)	firm-ness	fruit set	uniform ripening	
PT3017	25.1a-e	18.6a-e	45	M	P	P	C
PT3018	14.6d-f	7.3d-g	64	M	P-F	P	C
PT3019	34.7a-c	27.8ab	41	M	G	F	B+
PT3020	16.6c-f	10.6c-g	58	F	P	P	C
PT3021	17.5b-f	10.1c-g	57	F	P-F	P	C
PT3022	28.6a-e	7.1d-g	71	S-M	P-F	P	C
PT3023	31.4a-d	17.3a-f	54	S	F-G	F	B
PT3024	5.6f	2.0fg	65	M	VP	P	D
PT3025	36.1ab	22.4a-d	50	F	F-G	F	A
PT3026	34.9a-c	14.3b-g	55	S	F	P	C
PT3027	36.7a	30.8a	49	M	E	F-G	A
PT3028	17.3b-f	3.3e-g	64	S	P	P	C
PT677	21.3a-f	10.3c-g	56	S	F	P	C
TM103	30.6a-e	15.2b-g	73	M	F	F	C
PT858	32.4a-d	16.2a-g	95	S	F	F	C+
PT862	28.5a-e	15.3b-g	80	M	F	F	C
PT870	27.1a-e	14.2b-g	63	M	F-G	F	C+
PT1017	29.5a-e	25.1a-c	37	S	E	G	B
PT1599	23.3a-f	19.8a-d	35	S	E	G	B
PT1600	19.7a-f	15.7b-g	77	S-M	G	G	A
TK70(Ck1)	11.6ef	3.5e-g	65	S	P	F-P	
Tainan Sel No.2 (Ck 2)	4.9f	0.9g	50	F	P	F	

[2]Late sown: July 11, 1984, date transplanted: Aug. 10, 1984; date harvested: Oct. 27, 1984 to Nov. 15, 1984; experimental design: RCBD, two replications.

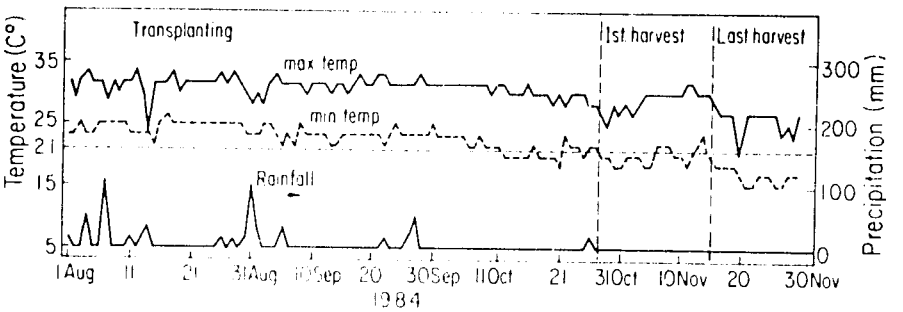


Fig. 1. Daily maximum and minimum temperatures and precipitation patterns at AVRDC from August to November 1984.

Verification for disease resistance. Table 2 shows the responses of 24 *F1* and open-pollinated (OP) selections and control cultivars to root-knot nematode inoculation. Most of the tested cultivars were found to be resistant, except five which were segregating. Parental lines of these segregating entries will be purified to stabilize their resistance.

Table 3 shows the response of 21 F1 and OP selections and control cultivars to seedling inoculation of Fusarium wilt race 1. All of the entries showed complete resistance as expected. All tested entries and the resistant checks, Floradel and Florida MH-1, did not wilt; whereas the susceptible check, Bonny Best, had 75% and 85% wilt.

The result of ToMV inoculation is shown in Table 4. Except PT677, most of the entries showed resistance to ToMV (Strain 1) ranging from 0 to 8.3% compared with 100% for the susceptible check, TK70. It seemed that the ToMV-resistant parental stock of PT677 was still segregating for ToMV resistance. In addition, as the F1's carry only the heterozygous form of Tm^{2a} gene, some of the plants showed minor mosaic symptoms, especially at high temperature.

Regional yield trials in 1983-84. Table 5 shows the yield summary of the nine trials conducted during 1983 to 1984. All of the AVRDC F1 hybrids consistently outyielded the local control cultivars, TK70 and Tainan Selection No. 2. For example, the mean yields in all trials of hybrid TM103 was 84.4 t/ha, 37% higher than that of Tainan Selection No. 2. The yield differences between the new selections and local checks were even higher when they were planted in early August. Under high temperature conditions in the late summer, most of the new F1's significantly outyielded the two local controls.

Similar results were also obtained in trials of four AVRDC F1 hybrids conducted by the processing factories in 1983. PT877 not only gave the highest yield, but also matured earlier and was the best yielder in this trial. This hybrid was also reported to have larger fruits with better firmness than TK70 (Table 6).

As in last year's report, most of the F1's also carried resistance to ToMV and some to nematode. They were also resistant (low level) to bacterial wilt in the seedling inoculation test. A summary list of the major characteristics and disease resistance of the elite F1 and OP selections are shown in Table 7.

Table 8 shows the days to maturity, fruit size, and fruit quality of the processing tomato entries in the regional yield trial. Several F1 selections matured about 10 days earlier than TK70 and Tainan Selection No. 2. The Hunter color reading of fruit pastes were comparable to the checks. Only a few hybrids has soluble solids higher than 5.00; this could be a major problem of the new hybrids. PT862 had the best processing quality of all new combinations in these trials.

Color development during the warm period did not appear to be a problem. In fact, all entries had slightly higher Hunter color reading in the early planting (Table 9). Fruits harvested in the warm season had higher soluble solids (Brix) and pH, and lower titratable acid concentration than during the cooler periods.

Table 2. Nematode resistance of F1 and open-pollinated processing tomatoes[z].

AVRDC Sel No / Cultivar Name	Genotype	Mean Rating[y]	Classification[x]	AVRDC Sel No./ Cultivar Name	Genotype	Mean Rating[y]	Classification[x]	AVRDC Sel No./ Cultivar Name	Genotype	Mean Rating[y]	Classification[x]
PT3021	Mi/+	2.08b	R	PT1599	–	4.12b	segregating	PT1575	–	2.91b	segregating
PT3022	"	2.04b	R	PT1562	–	2.54c	"	PT1572	Mi/Mi	1.87c	R
PT3018	"	1.99b	R	PT3028	–	2.00cd	"	PT1582	"	1.33cd	R
PT3023	"	1.91b	R	PT3027	–	1.87cd	"	PT1606	"	1.25cd	R
PT3020	"	1.62b	R	PT3026	Mi/+	1.54de	R	PT1564	"	0.95cd	R
PT3019	"	1.62b	R	PT1600	"	0.91ef	R	PT1579	"	0.91cd	R
PT3017	"	1.58b	R	PT1604	Mi/Mi	0.87ef	R	PT1565	"	0.54d	R
PT3024	"	1.37b	R	PT1565	Mi/Mi	0.67f	R	PT1572	"	0.53d	R
Tainan Sel. No. 2 (susceptible ck)		5.00a	S	Tainan Sel. No.2 (susceptible ck)	+/+	5.00a	S	Tainan Sel. No.2 (susceptible ck)	+/+	5.00a	S
VFN Bush (resistant ck)		1.50b	R	VFN Bush (resistant ck)	Mi/Mi	1.08ef	R	VFN Bush (resistant ck)	Mi/Mi	1.46cd	R
Cal Mart (resistant ck)		1.46b	R	Cal Mart (resistant ck)	Mi/Mi	0.75ef	R	Cal Mart (resistant ck)	Mi/Mi	0.87cd	R

[z]Date sown: Sept. 21, 1984, date inoculated: Oct. 11, 1984, date observed: Dec. 6 to 7, 1984. [y]Rated on a scale of 0 (free of galls) to 5 (>100 galls)
[x]R = resistant; S = susceptible

Table 3. Resistance to Fusarium of AVRDC processing tomato selections[z].

AVRDC Sel No./ Cultivar Name	Mean Plant Wilt[y] (%)	Classification[x]	AVRDC Sel No./ Cultivar Name	Mean Plant Wilt[y] (%)	Classification[x]
Group I			Group II		
PT3017	0	R	PT1600	0	R
PT3018	0	"	TK70	0	"
PT3020	0	"	Tainan Sel No. 2	0	"
PT3021	0	"	PT1601	0	"
PT3022	0	"	PT1605	0	"
PT3023	0	"	PT1607	0	"
PT3024	0	"	PT1608	0	"
PT1598 (TM103)	0	"	PT1615	0	"
PT862	0	"	PT1620	0	"
PT870	0	"	PT1570	0	"
Bonny Best (sus. ck)	75	S	Bonny Best (sus. ck)	83	S
Floradel (res. ck)	0	R	Floradel (res. ck)	8	R
Florida MH-1 (res. ck)	0	R	Florida MH-1 (res. ck)	0	R

[z]Sown on Sept. 25; inoculated on Oct. 8-9; and observed from Oct. 22 to 31, 1984. [y]Means of two replications, 12 plants per replication. [x]R = resistant; S = susceptible.

Table 4. ToMV resistance screening of processing tomato selections.

AVRDC Sel. No./ Cultivar Name	Genotype	Mean Infection Ratio (%)	AVRDC Sel. No./ Cultivar Name	Genotype	Mean Infection Ratio (%)
PT3022	$Tm2^a/+$	4.2	PT870	$Tm2^a/+$	0.0
PT3023	"	4.2	PT1017	"	0.0
PT3027	"	4.2	PT1599	"	0.0
PT3028	"	0.0	CL1131-0-0-38-4-0-1A	$Tm2^a/Tm2^a$	0.0
PT677	–	70.8	(res. check)		
PT1598 (TM103)	$Tm2^a/+$	0.0	Ohio MR-13		
PT858	"	8.3	(res. check)	"	0.0
PT862	"	4.2	TK70 (sus. check)	+/+	100.0

Tabel 5. Marketable fruit yield of processing tomato selections in regional yield trials in 1983-1984[z].

Entry	Transplanting Date			Mean	Index (%)
	Aug. 4-9	Oct. 12-15	Dec. 15		
	(t/ha)				
TM102	58.1	136.4	37.7	77.4ab	125
TM103	76.7	123.6	53.0	84.4a	137
PT867	63.1	116.2	49.5	76.3ab	124
PT870	66.1	129.9	41.5	79.2ab	128
PT873	58.5	126.7	47.0	77.4ab	125
PT857	70.8	127.0	41.2	79.7ab	129
PT858	66.4	120.4	40.9	75.9ab	123
PT862	59.9	132.8	41.6	78.1ab	127
CL2815-1-1-1-0-12	57.5	120.8	33.7	70.7bc	115
TK10 F1 (check)	76.9	115.8	35.9	76.2ab	124
TK70 (check)	43.6	109.9	35.0	62.8c	102
Tainan Sel #2 (check)	50.4	106.6	28.0	61.7c	100

[z]Regional yield trials were conducted at three planting dates in 1983 to 1984 in three locations in Southern Taiwan; the data are means of three locations in each planting date

Table 6. Performance of AVRDC and introduced processing tomatoes in a trial conducted by a processing company[z].

Entry	Marketable Yield (t/ha)	Maturity	Fruit Set	Firmness	Fruit Size
PT617	90.7	E	G	S	M
PT857	87.1	E	G	F	M
PT873	99.7	E	G	S	M
PT877	118.4	E	G	F	M-L
PT890	100.4	E	G	S	M-L
PT887	78.1	E	G	M	L
PT899	102.2	E	G	S	M-L
PT897	86.8	E	G	S	S-M
PT925	86.2	M	G	F	M
PT937	84.2	E	G	M	M
VFN8	49.0	E	P	S	L
UC204B	47.1	L	F	M	S-M
Euromech	80.6	L	F	F	M
Cal-Mart	43.2	L	F	S	L
TK70	68.8	M	G	S	M

[z]Data provided by the Taiwan Kagome Company, transplanted on October 22, 1983 at Chupu, Tainan.

Table 7. List of elite AVRDC processing tomato selections and their general characteristics.

AVRDC Sel.No.	Type	Growth Habit	Variety Description
TM103	F1	determinate	Medium to large fruit size, resistant to ToMV, V, F, medium tolerance to bacterial wilt and heat. high-yielding.
PT868	"	"	"
PT862	"	vigorous, determinate	"
PT3027	"	determinate	Small to medium fruit size, resistant to ToMV, Fusarium race 1; tolerant to bacterial wilt, highly resistant to heat, high-yielding.
PT1017	"	"	Small to mediu fruit size, resistant to ToMV, Fusarium race 1, highly resistant to heat.
PT1599	"	"	Small to medium fruit size, resistant to ToMV, highly resistant to heat.
PT913	"	"	Small and soft fruit size, resistant to ToMV, highly resistant to heat, high-yielding.
CL4656-2-0-3-1-NR	open-pollinated (OP)	"	Medium fruit size, resistant to root-knot nematode, medium resistance to heat.
CL4657-9-0-4R-(N)R-0	"	"	Medium fruit size, resistant to root-knot nematode, medium resistance to heat.
Tainan Sel.No.2	"	vigorous, determinate	Medium to large fruit size, resistant to Fusarium race 1. high-yielding.

Table 8. Days to maturity, fruit size, and fruit quality of processing tomato selections in the regional yield trial, 1983[z].

Entry	Days to Maturity	Fruit Size(g)	pH	Soluble Solid[y]	Titratable Acid (%)	Hunter Color Reading
TM102	138	67	4.3	5.3	0.43	2.55
TM103	128	65	4.3	4.6	0.40	2.47
PT867	132	65	4.3	4.8	0.44	2.44
PT870	131	65	4.3	4.7	0.43	2.48
PT873	132	73	4.3	4.9	0.39	2.42
PT857	134	67	4.3	5.0	0.41	2.56
PT858	130	79	4.3	5.0	0.40	2.50
PT862	131	75	4.3	5.4	0.41	2.55
CL2815-1-1-1-0-12	139	59	4.3	4.4	0.43	2.42
TK10 (F1)	133	74	4.3	4.9	0.49	2.54
TK70	141	71	4.3	5.3	0.48	2.45
Tainan Selection No.2	142	67	4.4	5.0	0.38	2.72
Mean	134	69	4.3	5.0	0.42	2.51

[z]Data are means of three planting dates. [y]Measured in °Brix

Conclusion

A series of F1 hybrid and open-pollinated processing tomatoes which produced fairly large fruits, and were resistant to tobacco mosaic virus, root-knot nematode, and bacterial wilt (low level) were developed. These selections also had the ability to set fruits under relatively high night temperatures (22° to 23°C).

In a regional yield trial conducted in late summer in Southern Taiwan, hybrid selection TM103 produced marketable fruits 74% higher than the most commonly used local cultivar,

Table 9. Fruit quality of processing tomato selections grown in different planting dates in Southern Taiwan[z]

Item	TK70			PT862			All Entries[y]		
	summer	fall	winter	summer	fall	winter	summer	fall	winter
pH	4.26	4.29	4.40	4.24	4.35	4.31	4.22	4.33	4.33
Soluble solid[x]	5.45	4.92	5.58	5.34	5.50	5.25	4.89	4.61	4.92
Titratable acid	0.46	0.45	0.51	0.34	0.43	0.46	0.40	0.43	0.44
Hunter color	2.62	2.43	2.31	2.79	2.50	2.37	2.61	2.48	2.44

[z]Transplanted at AVRDC on August 4, 1983 for summer, on October 12, 1983 for fall; and December 15, 1983 for winter plantings. [y]Mean of 10 varieties. [x]Measured in °Brix.

TK70, or 48% higher than the newly released AVRDC processing tomato cultivar, Tainan Selection No. 2. Some of these selections will be released in 1985 in Taiwan for early season production. Currently, these materials, including selections PT862, PT858, TM103, PT1017 and PT3027, are also being tested in Thailand, Malaysia, and the Philippines.

Inheritance Study of Heat Tolerance of Parthenocarpic Tomato

Introduction

Although tomatoes can be grown under a fairly wide temperature range, most cultivars have adequate fruit set only in a narrow range of night temperatures of approximately 15° to 21°C. As some genetically parthenocarpic lines showed good levels of heat resistance*, it was proposed that an excellent level of this trait may be obtained by combining the parthenocarpic trait with the genes for heat-tolerance of the AVRDC tropical lines.

This experiment was conducted to study the inheritance of heat tolerance in parthenocarpic tomatoes and the relationship between parthenocarpy and the heat-tolerant trait of various families with different genetic backgrounds.

Materials and Methods

The following tomato cultivars and lines and their progenies were used in this study:

Ventura-1-0(B)-1 (P_1)-a facultative parthenocarpic line which originated in Italy. The parthenocarpic trait of this line was reported to be controlled by a single recessive gene, *pat*.

CL1131-0-0-38-4-1A (P_2)-an AVRDC heat-tolerant breeding line. It is a seeded line (*pat*$^+$) with a high level of heat tolerance.

UC82B (P_3)-a seeded (*pat*$^+$) processing tomato cultivar from USA. It is heat sensitive and does not usually set fruits during the hot season at AVRDC.

The following eight families were the progenies of the above parents: F1A (P1 / P2); F1B (P1 / P3); F2A [(P1 / P2)-0]; F2B [(P1 / P3)-0]; BC-P1; BC-P2, F4A-seedless [(P1 / P2)-0-3-2]; F4B-seeded [(P_1 / P_2)-0-3-7].

* Lin Steve, W.E. Splittstoesser, and W.L. George, 1983. Factors controlling the expression of parthenocarpy in 'Severianin' tomato. Scientia Hort. 19:45-53.

Steve Lin, W.L. George, and W.E. Splittstoesser, 1984. Expression and inheritance of parthenocarpic in 'Severianin' tomato. J. of Heredity. 75:62-66.

Seeds were sown in sterilized soil on May 24, 1984. Forty plants each of the parental and F1 families were transplanted in the field next to 120 plants each of the segregating families on June 25, 1984 at 32 days after sowing. All plants were staked and pruned to a single stem. The number of fruit set from the 2nd to 5th clusters and the number of seeded and seedless fruits were observed.

The following calculations were made:

- Fruit set percentage = (no. of fruit/no. of open flowers) × 100. Mean fruit set per plant was calculated based on mean fruit set of the 2nd to 5th clusters. Mean fruit set per family was calculated by the mean of all surviving plants in the family.
- Heat-tolerant segregates = plants with mean fruit set larger than the mid-parent.
- Heat-sensitive segregates = plants with mean fruit set smaller than the-mid parent.
- Seedless segregates = plants with 100% seedless fruit.
- Partially seeded segregates = plants with more than one seedless fruit.
- Seeded segregates = plants with 100% seeded fruits.

Results

Expression of seedlessness. The expression of seedlessness in the facultatively parthenocarpic line, Ventura-1-0(B)-1, was close to 100% (Table 12). Among the 18 plants which set fruits, 17 had 100% seedless fruits. Only one plant produced a one-seeded fruit. The two-seeded parental lines, UC82B and CL1131-0-0-38-4-0-1A, were all seeded. None of the plants produced any seedless fruits (Table 11). The complete expression of seedlessness in the parental line provided an excellent opportunity to classify the parthenocarpic and nonparthenocarpic plants in the segregating progeny populations of the Ventura / CL1131-0-0-38-4-0 and Ventura / UC82B crosses.

In the progeny populations, some plants produced both seeded and seedless fruits in the same plant (Table 12). As this partial expression of seedlessness was different from the expression of the parthenocarpic parental line Ventura-1-0(B)-1, it was classified as seeded segregate in the genetical analysis. However, only the F2 and BC-P1 populations had an unusually high percentage of partially seeded segregates and, thus, the partially seeded (or partially seedless) plants were classified as an intermediate class in further analysis (Table 13).

Inheritance of parthenocarpic trait. The segregation of seeded, partially seeded, and seedless plants in the parental, F1, F2, backcross (BC), and F4 populations are listed in Table 14. Although it has been reported that a single recessive gene, *pat*, conditions the seedlessness in cv. Ventura (Soressi, 1975), the X^2 analysis for the segregation of seeded and seedless plants in the present study did not agree with the single-gene hypothesis.*

A further evidence to reject the single-gene hypothesis was that only the F2 and BC-P1 families had an unusually high frequency of partially seeded segregates. This indicated that other genetic factors besides the gene *pat* may be involved in the expression of parthenocarpy in Ventura. The number of factors involved in controlling the seedless trait in Ventura is purely speculative in the present study. However, these factors seemed to be recessive because the F1 and BC-P2 populations had only very few partially seeded plants.

The complete expression of seedlessness in one F4 line also indicated that the additional factors (minor genes or modifiers) were probably not too many. The partially seeded trait was easily evident after two generations of selection for a completely seedless type (Tables 10, 11, 12).

Heat-tolerant trait. Table 10 shows the mean fruit-set percentages of all families. The F4 selection, (Ventura / CL1131)-0-3-2, had the highest mean fruit-set, followed by the backcross family CL1131 / (Ventura / CL1131). Table 12 shows the number of plants in

* Soressi, G.P. and F. Salamini, 1975. A monomendelian gene inducing parthenocarpic fruits. Tomato Genet. Coop. 25:22.

each segregating family which gave better fruit set than their parental cultivars. The F4 parthenocarpic family, (Ventura / CL1131)-0-3-2, had the highest number of segregates and showed superior heat tolerance than the heat-tolerant parental line, CL1131-0-0-38-4-0-1A. These results indicated that the parthenocarpic tomato cultivar combined very well with the heat-tolerant cultivar. It is thus possible to select better heat-tolerant genotypes from the progenies of parthenocarpic and heat-tolerant cultivars.

Relationship between parthenocarpy and heat tolerance. The mean fruit set of the two F2 Ventura families crossed with heat-sensitive UC82B, and with heat-tolerant CL1131-0-0-38-4-0-1A, were similar (Table 11). However, most of the heat-tolerant plants in the F2 of Ventura × UC82B were also parthenocarpic segregates. Thus, only the parthenocarpic segregates were resistant to heat in this line.

On the contrary, most of the heat-tolerant plants in the F2 of Ventura / CL1131 were seeded (Table 14). The parthenocarpic trait did not contribute as much to the heat tolerance in this cross as in the Ventura / UC82B family. However, most of the plants which showed excellent fruit set belonged to the partially seeded class, implying that parthenocarpy may, in fact, have contributed to the increased fruit set in the partially seeded segregates (Table 15).

Based on the fruit set data of Ventura, CL1131-0-0-38-4-0-1A, F4 and F2 families, the genetically parthenocarpic tomatoes were equal to or better in heat resistance than the AVRDC heat-tolerant cultivar. The question is if genetic parthenocarpy and traditional heat tolerance can be combined to further improve fruit set under high temperatures.

Theoretically, it should be possible to select different degrees of seedlessness. In the F2 and BC-P1 progenies of Ventura / CL1131, the partially-seeded plants had the highest fruit-set percentage (Table 15). This meant that high mean fruit set was actually contributed by these parthenocarpic segregates and, thus, it is possible to incorporate an optimum level of seedlessness into the traditional heat-tolerant lines to obtain the highest degree of heat resistance.

Conclusion

The data in this trial showed two important facts:

1. There are differences in the expression of seedlessness in different families, and the intermediate type (partially seedless) seemed to have the best ability to set fruit under high temperature condition. Monogenic control of parthenocarpy is thus questionable.
2. In the completely parthenocarpic lines, there were also differences in the ability to set fruit under high temperature.

It may be hypothesized that the partially seeded genotypes perform better under unfavorable conditions than either the completely seeded or the parthenocarpic genotypes because they can attain the required sink strength for successful set (Fig. 2). This theory assumes that the completely seeded genotypes create their sink strength through the normal reproductive process (pollination/fertilization/fruit and seed development), whereas parthenocarpic genotypes rely on the sink strength which already exists in the ovary (under hormonal control?) even in the absence of successful pollination.

The partially seeded genotypes may thus have the advantages from both parents, i.e., they have a lower requirement of sink strength to fill because they already contain a certain amount of growth promotor in the ovary (inherited from the parthenocarpic parent) and they also have a better ability to attain a normal reproductive process (derived from the seeded parent). The above combination of both traits presumably results into a partial expression of seedlessness and a better fruit set under adverse environment.

Although it is theoretically possible to improve the fruit set of either the completely seeded or the parthenocarpic types through selection (larger I_i for the completely seeded type or larger m for the seedless type; see Fig. 2), the best approach appears to be to select the partially seeded genotype type. This type would require only a few seeds to support fruit set under adverse environment.

Table 10. Number of seedless plants in various tomato families.

PT No.	Name/Pedigree	Generation	Total	Plant No. seeded (< 100%)	Plant No. seed-less (= 100%)	Plant No. seeded (< 3 seed-less fr.)	Plant No. seedless (< 3 seed-less fr.)
PT1453	Ventura-1-0(B)-1	P1	18	1	17	0	10
PT1504	CL1131-0-0-38-4-0-1A	P2	39	39	0	35	0
PT1064	UC82B	P3	3	2	1	0	0
PT913	Ventura/CL1131	F1A	38	38	0	38	0
PT996	Ventura/UC82B	F1B	21	19	2	6	0
PT1359	(Ventura/CL1131)-0	F2A(P1/P2-0)	86	75	11	42	18
PT0005	(Ventura/UC82B)-0	F2B(P1/P3-0)	71	22	49	4	36
PT1419	Ventura/(Ventura/CL1131)	BC-P1	98	78	20	49	17
PT1421	CL1131/(Ventura/CL1131)	BC-P2	104	104	0	104	0
PT1417	(Ventura/CL1131)-0-3-2	F4A	91	0	91	0	90
PT1477	(Ventura/CL1131)-0-3-7	F4B	77	3	74	1	58

Table 11. Average fruit set, fruit number, seedless fruit number, and percentage in various tomato families.

PT No.	Name/Pedigree	Generation	Fruit Set (%) range	Fruit Set (%) mean	Seedless Fruit (%) range	Seedless Fruit (%) mean	Total Fruit No. (no./pl.) range	Total Fruit No. (no./pl.) mean	Seedless Fruit No. (no./pl.) range	Seedless Fruit No. (no./pl.) mean
PT1453	Ventura-1-0(B)-1	P1	0-87.5	16.0	0-100	94.4	0-27	8.7	0-27	8.6
PT1504	CL1131-0-0-38-4-0-1A	P2	2.9-42.9	23.0	0	0	1-16	7.4	0	0
PT1064	UC82B	P3	0-1.8	0.15	0-100	33.3	0-1	0.1	0-1	0.3
PT913	Ventura/CL1131	F1A	0-50.2	22.4	0	0	0-13	7.1	0	0
PT996	Ventura/UC82B	F1B	0-23.2	5.8	0-100	11.9	0-8	1.6	0-2	0.3
PT1359	(Ventura/CL1131)-0	F2A(P1/P2-0)	0-46.2	14.3	0-100	25.8	0-20	4.2	0-15	1.9
PT0005	(Ventura/UC82B)-0	F2B(P1/P3-0)	0-76.3	13.0	0-100	73.9	0-27	4.7	0-27	6.0
PT1419	Ventura/(Ventura/CL1131)	BC-P1	0-68.6	12.4	0-100	23.8	0-28	5.1	0-28	2.1
PT1421	CL1131/(Ventura/CL1131)	BC-P2	7.3-65.6	35.6	0-50	1.0	0-26	13.1	0-2	0.1
PT1417	(Ventura/CL1131)-0-3-2	F4A	0-64.6	36.4	0-100	100	0-21	11.4	0-21	11.3
PT1477	(Ventura/CL1131)-0-3-7	F4B	0-81.0	23.7	0-100	97.5	0-24	6.6	0-24	7.1

Table 12. Segregation of the parthenocarpic trait in the progenies of Ventura/UC82B and Ventura/CL1131-0-0-38-4-0.

PT No.	Name/Pedigree	Generation	Plant No					Chi-square[z]	P[y]
			Total	Seeded					
				total seeded	comp-letely	par-tially	sc-d-less		
PT1453	Ventura-1-0(B)-1	P1	18	1	(1	0)	17		
PT1504	CL1131-0-0-38-4-0-1A	P2	39	39	(39	0)	0		
PT1064	UC82B	P3	3	2	(2	0)	1		
PT913	Ventura/CL1131	F1A	38	38	(38	0)	0		
PT996	Ventura/UC82B	F1B	21	19	(17	2)	2		
PT1359	(Ventura/CL1131)-0	F2A(P1/P2-0)	86	75	(51	24)	11	6.84	0.01-0.005
PT0005	(Ventura/UC82B)-0	F2B(P1/P3-0)	71	22	(16	6)	49	73.36	0.005
PT1419	Ventura/(Ventura/CL1131)	BC-P1	98	78	(52	16)	20	34.33	0.005
PT1421	CL1131/(Ventura/CL1131)	BC-P2	104	104	(99	5)	0		
PT1417	(Ventura/CL1131)-0-3-2	F4A	91	0	(0	0)	91		
PT1477	(Ventura/CL1131)-0-3-7	F4B	77	3	(1	2)	74		

[z]Ho: F2 = 3-seeded : 1 seedless, BC = 1 seeded : 1 seedless [y]P = probability level

Table 13. Segregation of heat tolerance (fruit set) in the progenies of Ventura/UC82B and Ventura/CL1131-0-0-38-4-0-1A.

PT No.	Name/Pedigree	Generation	Plant No.				Percentage over $\bar{P}2$
			Total	fruit set (%)[z]			
				$\bar{P}1$	$\bar{P}2 \times \bar{P}1$	$\bar{P}2$	
PT1453	Ventura-1-0(B)-1	P1	33	25	0	8	24
PT1504	CL1131-0-0-38-4-0-1A	P2	39	13	10	16	41
PT1064	UC82B	P3	31	31	0	0	0
PT913	Ventura/CL1131	F1A	39	13	11	15	39
PT996	Ventura/UC82B	F1B	32	27	4	1	3
PT1359	(Ventura/CL1131)-0	F2A(P1/P2-0)	99	62	12	25	25
PT0005	(Ventura/UC82B)-0	F2B(P1/P3-0)	98	73	2	23	24
PT1419	Ventura/(Ventura/CL1131)	BC-P1	104	75	13	16	15
PT1421	CL1131/(Ventura/CL1131)	BC-P2	104	8	14	82	79
PT1417	(Ventura/CL1131)-0-3-2	F4A	92	5	13	74	80
PT1477	(Ventura/CL1131)-0-3-7	F4B	85	44	9	32	38

[z]Mean fruit set:

P1	P2	P3
UC82B	Ventura	CL1131-0-0-38-4-0-1A
0.15%	16.0%	23.0%

Table 14. Segregation of heat tolerant and parthenocarpic traits in F2 and backcross families.

Family	Generation	Heat Tolerant				Heat-Sensitive				Total
		seeded	seed-less	Chi-Square[z] 3:1:F2 (1:1:BC)	P[y]	seeded	seed-less	Chi-Square[z] 3:1:F2 (1:1:BC)	P[y]	
(Ventura/UC82B)-0	F2	5	34	78.8	< 0.005	17	15	8.2	< 0.005	71
(Ventura/CL1131)-0	F2	25	4	1.9	0.1-0.5	50	7	4.9	.025-.05	86
Ventura/(Ventura/CL1131)	BC	14	9	1.1	0.1-0.5	63	12	34.7	< 0.005	98

[z]Ho: F2 = 3-seeded: 1 seedless; BC = 1 seeded: 1 seedless. [y]P = probability level.

Table 15. Fruit set and mean fruit number of seeded, partially seeded, and seedless segregates in various tomato families.

Classification	Ventura P1	CL1131-0-38-4-0-1A P2	UC82B P3	Ventura /CL1131 F1A	Ventura /UC82B F1B	(Ventura /CL1131)-0 F2A	(Ventura /UC82B)-0 F2B	Ventura /(Ventura /CL1131) BC-P1	CL1131/ (Ventura /CL1131) BC-P2	(Ventura /CL1131) -0-3-2) F4A	(Ventura /CL1131) -0-3-7 F4B
Completely seeded											
Mean fruit set (%)	3.0	23.0	1.5	22.4	5.6	13.8	5.2	9.6	35.5	–	11.5
Mean fruit no./plant	1	7.4	1	7.1	1.5	3.8	1.4	3.9	13.2	–	1
Partially seeded[z]											
Mean fruit set (%)	–	–	–	–	8.8	22.9	9.1	16.2	35.8	–	11.7
Mean fruit no./plant	–	–	–	–	2.5	15.9	4	7.4	11.8	–	3.5
Completely seedless											
Mean fruit set (%)	30.9	–	1.8	–	4.5	14.9	23.2	22.3	–	36.3	26.8
Mean fruit no./plant	9.1	–	1	–	2.0	5	8.4	8.7	–	11.5	7.5
Mean fruit set (%)	16.0	23.0	0.15	22.4	5.8	14.3	13.0	12.4	35.6	36.4	23.7

[z]Partially seeded: the percentage of seedless fruits per plant (x) equals: $0\% < x < 100\%$.

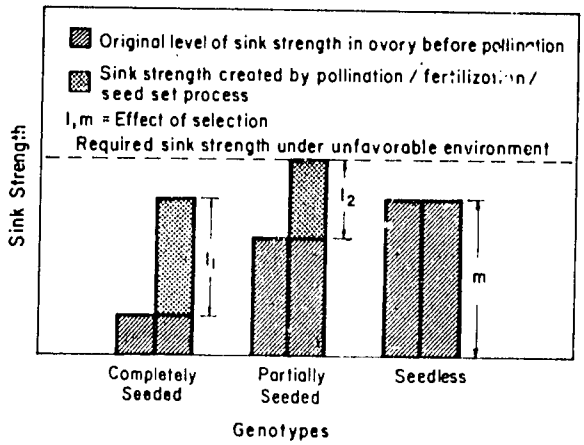


Fig. 2.
Sink strength for fruit set of three tomato genotypes under an unfavorable environment.

Sweet Potato Breeding

Hybridization

A total of 94,717 sweet potato seeds was collected during the cool season in 1983-84 from various crossing nurseries (Table 1). As in the previous year, three types of hybridization—hand crosses, open-pair pollination, and polycrosses—were conducted. As there were still plenty of seeds left from last year's crosses, this year's hybridizations concentrated mainly on raising dry-matter yield for feed/industrial uses and on improving eating quality and flavor for human consumption.

Table 1. Objectives and number of seeds produced from the 1983 (fall) sweet potato hybridization program.

Crossing Type/Objective	No. of Combinations	No. of Seeds Harvested	No. of Seeds Sown
Hand crossing			
To combine high yield, high DM with better eating quality	46	5,184	4,777
To improve dryness and flavor of dessert lines and to improve dry matter yield	24	719	633
Sub-total	70	5,903	5,410
Open pair			
To obtain high dry matter lines	1	569	376
To improve dry matter yield	1	23,952	8,000
Sub-total	2	24,521	8,376
Polycross			
To obtain high dry matter lines	–	357	0
To improve dryness and flavor of dessert lines	–	4,820	2,891
Sub-total	–	5,177	2,891
Open pollination	–	59,116	51,493
Total		94,717	68,170

Seedling Screening and Observational Trials

Introduction

During the 1983-84 cool season, a total of 94,717 sweet potato seeds from various hybridization nurseries was successfully collected. The lack of rapid and reliable screening techniques was a major limitation of the program.

In order to handle a large number of clones, rigorous selection was imposed in the seedling stage and in the first vegetatively-propagated stage to reduce the number of subsequent yield trials.

Materials and Methods

Seedling screening. A total of 68,170 seeds was sown in two separate trials. The first set of 30,393 seeds was sown in the field on March 19 and screened on August 14, 1984. The second set of 37,777 seeds was sown on June 14 and screened on December 10, 1984. A total of 6,557 seedlings was selected from the above materials on the basis of flesh and skin color, appearance and shape of storage roots, and plant type. In addition, two other seedling screening techniques were used to identify superior genotypes in the field: rapid dry-matter determination and rapid protein determination.

Immediately after seedling screening, cuttings of the selected clones were transplanted to the field for multiplication of planting materials eventually needed for observational trials.

Observational trials. A total of 3,028 clones selected from seedling screening in 1982 was grown from November 29, 1983 to April 10 to 13, 1984 for observation of yield and horticultural characteristics. Five cuttings of each clone obtained from the multiplication plots were transplanted to the field, spaced at 0.4 m between hills and 1 m between rows. Two check cultivars, Tainan 18 and AIS0122-2, were planted after every 40 clones. Selections were based on yield, dry matter content, dry matter yield, and appearance and uniformity of storage roots. The selected clones were grouped into orange-fleshed clones and yellow or white clones for further selections.

Results

Seedling screening. In the first set, only 2,692 seedlings were selected for observational trials (Table 2). From the second set composed mainly of seeds from hand crosses, open pairs and polycrosses, 3,865 seedlings were selected for further trials. The mean selection rate in these populations was slightly higher than in the first set.

Table 2. Seedling screening in 1984.

Item	No. of Seeds Sown	Selection	
		no.	rate (%)
Seedling screening I[z]	30,393	2,692	8.9
open pollination			
Seedling screening II[y]	37,777	3,865	10.2
controlled crosses	(5,410)		
open paired (high DM & DM yield population)	(8,376)		
polycross (high DM population)	(2,891)		
open pollination	(21,100)		
Total	68,170	6,557	

[z]Seeds were sown on March 19, 1984 and selected on August 14, 1984. [y]Seeds were sown on June 14, 1984 and selected on Dec. 10, 1984.

Observational trials. Fig. 1 shows the population number and mean marketable root yield of the original, the first, and the final selections. Dry matter contents of the first and the final selections are shown in Fig. 2.

The original population was selected from seedling screenings in 1982. The first selection was conducted in the field based on yield, root shape and uniformity, and on number of marketable roots per plant. The last selection was made on the basis of dry matter content. The mean dry matter yield of this population (23.5 t/ha) was higher than in any of the observational trials in the past.

The high-protein population selected by the rapid-field protein-determination technique is still being evaluated for stability of protein content under field conditions. The results will be reported next year.

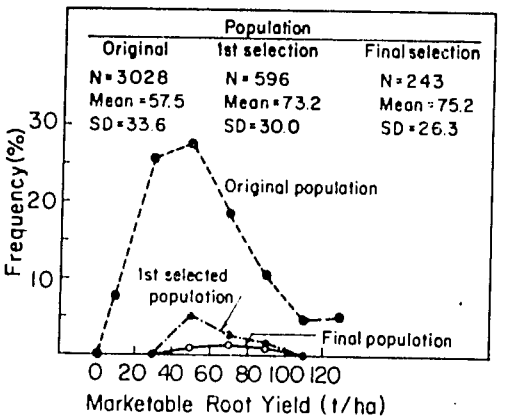


Fig. 1. Distribution of marketable root yield of sweet potato clones grown in observational trials before and after selection in 1983.

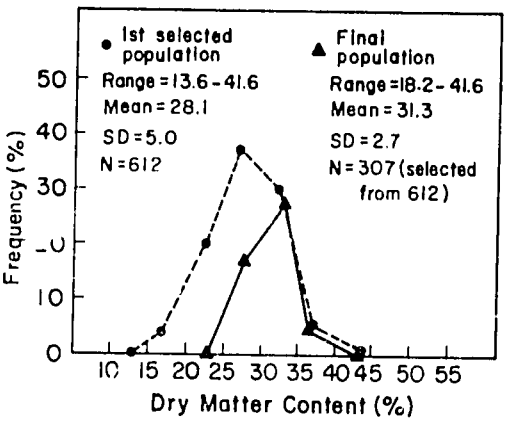


Fig. 2. Distribution of dry matter content of selected sweet potato clones grown in observational yield trials in summer, 1983.

Conclusion

Except for a few nonflowering cultivars, such as the stem-borer resistant cultivars I55 and I92, sufficient hybrid seeds were successfully produced through controlled crosses, open-pair crosses, and polycrosses. Application of multiple selection criteria at various stages of breeding resulted in a substantial narrowing down of total population size from the above crosses. Among the 1982 seedling populations selected in this manner, considerable improvement in dry matter percentages and dry matter yield was observed. The latter was higher than dry matter yields obtained in previous trials.

Preliminary and Advanced Yield Trials in 1983 and 1984

Introduction

Preliminary and advanced yield trials are usually conducted at AVRDC for two seasons: in the favorable environments of the cool-dry season and in the adverse hot-wet season. Selections are based on overall performance in both trials during these two seasons. The selected entries are then tested in Taiwan in multi-locational trials to determine the stability of yield and other characteristics before sending them to foreign cooperators.

Materials and Methods

A total of 175 entries was evaluated in the 1983 preliminary yield trials (PYT) in the wet (summer) and dry (fall) seasons. The wet-season trials were planted on July 11 and harvested from October 12 to 20, 1983. The same entries were transplanted on October 14, 1983 and harvested on April 24, 1984 during the dry season. Entries in both trials were divided into 16 groups according to their utilization type and previous performance.

The randomized complete block (RCB) design with two to three replications was used in all trials. The plot size was 10 m^2 (40 plants). Selections CN1108-13, AIS35-2, and 1981 (Tainung 66) were used as control cultivars for the dessert/staple groups; and selections CN1038-16, 1981, and I424 (Tainan 18) were used as control cultivars for the feed/starch groups.

A total of 352 entries in observational trials in 1982 was selected for the preliminary trials in the 1984 wet season. The entries were classified into 22 groups and evaluated from May 23 to November 5, 1984 at AVRDC. The experimental design and plot size were the same as in the 1983 PYT.

The advanced yield trials were conducted in two locations, Chishan and Shalu, during the 1984 wet season. They were transplanted on June 11 and harvested on November 6, 1984 in Chishan, and transplanted on June 13 and harvested on November 20 in Shalu.

Results

Preliminary trials in 1983. Tables 3 to 5 show the results of the Preliminary trials in 1983 preliminary trials conducted in two seasons during 1983. The elite and secondary selections suitable for human consumption are listed in Table 3 and Table 4. Selections CN1424-36 and CN1421-153 had mean yields of more than 30 t/ha in two seasons. Their dry matter yields were also higher than those of the control cultivars. Most of the elite selections listed in Table 3 also had good root shape and uniformity, and rated fair to good on taste

Table 3. Horticultural characteristics and yields of elite dessert/staple lines selected from preliminary trials in summer and fall 1983.

Entry Name	Taste	Grade	Yield(t/ha)			Dry Matter (%)			DMY[x]
			summ[z]	fall[y]	mean	summ[z]	fall[y]	mean	(t/ha)
CN1424-36	G-E	A	24.9	42.1	34.0	30.1	24.8	27.5	9.2
CN1421-56	G-E	A	15.8*	26.6	21.2	31.8	31.7	31.8	6.7
CN1421-68	F	A	17.5	20.4	19.0	34.6	32.5	33.6	6.4
CN1421-153	F	A	19.6	43.9	31.8	27.3	24.0	25.7	8.2
CN1423-438	F	B	11.2	33.9	22.6	26.6	26.3	26.5	6.0
CN1424-9	G	B	16.9	30.0	23.5	26.5	26.3	26.4	6.2
CN1419-139	P-F	B	16.9	24.5	20.7	35.8	31.2	33.5	6.9
CN1108-13(Ck1)	G	A	12.7	37.4	25.2	24.9	27.9	26.4	6.6
AIS35-2(Ck2)	F	A	15.0	30.5	27.8	24.8	24.3	24.6	6.8
I981(Ck3)	G	A	22.3	22.9	22.6	28.7	30.6	29.7	6.7

[z]Transplanted on July 11, 1983, harvested on Dec 12-20, 1983, replicated two to three times.
* = significantly higher than the superior control at p = 0.05 in the same group.
– = significantly lower than the superior control at p = 0.05 in the same group.
[y]Transplanted on Oct 24 1983, harvested on April 24, 1984, replicated two to three times.
[x]Dry matter yield.

Table 4. Horticultural characteristics and yields of the secondary dessert/staple lines selected from preliminary yield trials in summer and fall 1983.

Entry Name	Taste	Grade	Yield(t/ha)			Dry Matter (%)			DMY[x]
			summ[z]	fall[y]	mean	summ[z]	fall[y]	mean	(t/ha)
CN1308-1	G	C	21.7	16.4	19.1	29.1	26.7	27.9	5.3
CN1423NL-31	P	C	5.8	25.2	15.5	28.8	30.6	29.7	4.6
CN1424-3	F-G	C	8.4	22.5	15.5	31.6	30.6	31.1	4.8
CN1421-132	P	C	10.2	28.9	19.6	32.5	23.8	28.2	5.5
CN1423-170	F	C	19.8	40.4	30.1	28.1	24.8	26.5	8.0
CN1423-99	F	C	22.8	35.8	29.3	31.8	29.5	30.7	9.0
CN1421-243	F	C	18.3*	35.5	26.9	35.7	33.5	34.6	9.3
CN1330-11	G	–	6.5	26.4	16.5	25.2	–	25.2	4.1
CN1108-13(Ck1)	G	A	12.9	37.4	25.2	24.9	27.9	38.9	9.8
AIS35-2 (Ck2)	F	A	15.0	30.5	22.8	24.8	24.3	24.5	5.6
I981 (Ck3)	G	A	22.3	22.9	22.6	28.7	30.6	30.0	6.8

For footnotes, see Table 3.

score in the panel test. Selections CN1423-170 and CN1423-98, selected from the Co^{60} treated populations in 1982, yield around 30 t/ha in the preliminary yield trials (Table 4).

Clones which had superior dry matter content and dry matter yield were selected for further evaluation as feed or starch cultivars. Fifteen selections were chosen for these uses in the 1983 preliminary trials. The dry matter yield of these selections ranged from 6.1 to 14.5 t/ha compared to 6.8 to 9.0 t/ha of the control cultivars. Selection CN1309-18, with a mean yield in two seasons of 54.5 t/ha and dry matter yield of 14.5 t/ha, was identified as a potential animal-feed cultivar.

Based on the overall performance in different trials and on important characteristics such as taste, appearance, flesh and skin color, the 30 selected clones were graded from A to C. Only the A or B selections will be further evaluated.

Preliminary yield trials in 1984. The yields and characteristics of the 11 best selections from the 309 entries of the 1984 wet-season preliminary yield trials are shown in Table 6. These populations were found to be better than the PYT lines of the previous year. Marketable root yield and dry matter content of the elite lines were generally better than those of the control cultivar, Tainung 66. Five of the elite selections were orange-fleshed, the rest were yellow-or white-fleshed. All these lines had good root shape and uniformity.

The secondary selections are listed in Table 7. Further selections will be based on the overall performance in both dry and wet seasons in spring 1984.

Advanced yield trials in 1984. Table 8 shows the combined results of four trials conducted in 1983 and 1984. Most of the selected lines did not outperform the control cultivars selected in the previous year. The overall means of these new lines ranged from 18 t/ha to 33 t/ha compared with 24 t/ha of the superior control cultivar, CN1038-16. Only CN1309-18 significantly outyielded CN1038-16 in the combined analysis. Both of the AYT wet-season trials conducted outside AVRDC were severely infested by weevils and stem borers. These trials were repeated in the dry season at AVRDC.

Fig. 3 shows the yield stability of the entries grown in four environments. Most of the high-yielding cultivars had high regression coefficients (b). High-yielding lines which could perform equally well under both favorable and unfavorable environments seemed difficult to obtain.

Table 5. Horticultural characteristics and yields of feed/starch lines selected from preliminary yield trials in summer and fall 1983.

Entry Name	Taste	Grade	Yield(t/ha)			Dry Matter (%)			DMY[x]
			summ[z]	fall[y]	mean	summ[z]	fall[y]	mean	(t/ha)
CN1345-8	D	A	21.8	25.9	23.9	32.5	33.9	33.2	7.9
CN1407-8	F-G	A	15.4	51.3	33.4	31.3	29.8	30.6	10.2
CN1423-557	P	B	21.5	31.6	26.6	35.1	28.2	31.7	8.4
CN1309-18	F-P	B	34.2	74.7	54.5	30.6	22.8	26.7	14.5
CN1306-22	G	C	6.9	25.6	16.3	36.9	37.0	37.0	6.1
CN1424NL-18	G	C	7.1	26.3	16.7	32.3	32.8	32.6	5.4
CN1310-5	P	C	11.7	32.8	22.3	33.1	29.5	31.3	7.0
CN1423-215	F	C	26.1	46.5	36.3	28.1	22.2	25.2	9.1
CN1419-193	F-P	C	15.1	34.2	24.7	35.8	29.6	32.7	8.1
CN1419-165	F	C	13.6	41.0	27.3	32.8	27.8	30.3	8.3
CN1419-224	F	C	20.0	12.1	16.1	36.8	31.9	34.4	5.5
CN1388-7	F	C	1.2	41.9	21.6	34.9	28.8	31.9	6.9
CN1346-9	P	C	13.8	44.2	29.0	34.2	29.6	31.9	9.3
CN1310-23	F	C	17.4	58.0	37.7	28.0	23.9	26.0	9.8
CN1405-14	F	C	18.6	40.0	29.3	33.6	31.8	32.7	9.6
CN1038-16(Ck1)	F	A	14.6	52.6	33.6	28.6	24.9	26.8	9.0
I424(Ck2)	G	A	6.1	49.5	27.8	26.1	27.9	27.0	7.5
I981(Ck3)	G	A	22.3	22.9	22.6	28.7	30.6	30.8	6.8

For footnotes, see Table 3

Table 6. Yield and characteristics of the best breeding lines selected from preliminary trials in the wet season of 1984.[z]

Entry Name	Growth Habit	Appear-ance	Unifor-mity	Flesh Color	MKT[y] Yield (t/ha)	Root No. (x 1000/ha)	DM[x] (%)	DMY[w] (t/ha)
CN1517-122	S-P	G	G	Y3O1	23.0	92.4	34.4	7.9
CN1524-112	E	G	G	Y4O1	22.0	135.3	27.7	6.2
CN1489-95	E	G	G	Y3	32.2	175.2	36.6	11.8
CN1517-105	E	G	G	O3Y1	23.5	177.2	32.9	7.7
CN1517-164	S-E	G	G	Y2	31.4*	181.4	33.4	10.5
CN1486-24	S-E	G	G	W	25.6*	158.8	35.8	9.2
CN1434-2	S-P	G	G	Y4O1	32.0*	90.7	35.7	11.4
CN1524-230	S-P	G	G	Y2	28.8	147.7	36.0	10.4
CN1525-11	S-E	G	G	Y5	30.7*	185.7	29.9	9.2
CN1525-22	S-P	G	G	O4Y3	25.3	107.0	32.6	8.2
CN1438-39	S-P	G	G	Y2	24.2	93.7	37.5	9.1
Tainung 66[v]	S-E	F	G	O4Y3	19.7	150.3	27.8	5.5
CN1108-13[v]	S-E	F	G	O3Y3	16.5	109.5	23.0	3.8

[z]Selected from 309 entries, transplanted on May 23, 1984; harvested on Nov. 5, 1984; replicated two to three times.

[y]Market yield:

* = significantly higher than the superior control cultivar at p = 0.05 in the same group.

– = significantly lower than the superior control cultivar at p = 0.05 in the same group.

[x]Dry Matter. [w]Dry matter yield. [v]Common control cultivar used in all groups.

Table 7. Yield and characteristics of the secondary breeding lines selected from preliminary trials in the wet season of 1984.[z]

Entry Name	Growth Habit	Appear-ance	Unifor-mity	Flesh Color	MKT[y] Yield (t/ha)	Root No. (x 1000/ha)	DM[x] (%)	DMY[w] (t/ha)
CN1510-116	E	G	G	O3	27.9	256.0	24.1	6.7
CN1517-131	E	F-G	F-G	O3(Y3)	27.9	123.0	31.4	8.8
CN1425-3	S-E	G	G	Y6	14.9	115.6	35.1	5.2
CN1428-18	B	G	G	Y3	12.3	94.8	34.1	4.2
CN1517-126	E	G	G	Y2	22.7	121.2	33.0	7.5
CN1438-26	S-P	G	G	Y2	25.0	115.7	39.0	9.8
CN1489-79	S-E	G	G	Y2	27.5	158.3	37.3	10.3
CN1522-89	E	G	G	Y2	16.9	94.9	33.2	5.6
CN1524-65	S-E	G	G	Y2	23.2	106.3	34.3	8.0
CN1429-33	S-P	F	F	O3	23.0	173.1	26.0	6.0
CN1448-13	S-E	G	G	Y2	26.7	196.7	36.0	9.6
CN1449-26	E	G	G	Y1	20.3	122.7	37.2	7.6
CN1538-12	E	G	G	Y1(P1)	22.2	147.2	39.8	8.8
CN1525-87	E	F	F	O4Y3	24.4	191.4	33.9	8.3
CN1489-22	S-E	F	F	Y1	20.7	142.0	39.1	8.1
CN1429-134	S-E	G	G	O2Y1	33.8*	105.2	24.7	8.3
CN1448-62	E	G	G	Y2	20.2	98.9	33.7	6.8
CN1508-265	S-E	G	G	Y2	33.5	240.1*	28.9	9.7
CN1489-43	S-P	G	G	Y2	24.6	122.2	34.5	8.5
CN1510-25	S-E	F	F	Y2	29.6*	213.5*	32.6	9.6
CN1517-139	S-E	G	F	Y3	32.1*	119.9	35.8	11.5
CN1438-13	S-E	G	G	Y2	15.1	126.9–	34.1	5.1
Tainung 66[v]	S-E	F	G	O4Y3	19.7	150.3	27.8	5.5
CN1108-13[v]	S-E	F	G	O3Y3	16.5	109.5	23.03	3.8

[z]Selected from 309 entries, transplanted on May 23, 1984, harvested on Nov. 5, 1984; replicated two to three times.

[y]Symbol * = significantly higher than the control at p = 0.05 in the same group.

– = significantly lower than the control at p = 0.05 in the same group.

[x]Dry matter. [w]Dry matter yield. [v]Common control cultivar used in all group

Table 8. Yield and characteristics of elite sweet potato lines selected from two years of trials in 1983 and 1984.

AVRDC Sel. No./ Variety Name	Marketable Yield (t/ha)[z]					DM (%)	DMY (t/ha)
	'83 wet (AVRDC)	'83 dry (AVRDC)	'84 wet (Kinshan)	'84 wet (Shalu)	mean		
CN1424-36	24.9	42.1	8.8⁻	10.2⁻	21.5	27.1	5.8
CN1421-153	19.6	43.9⁻	4.7⁻	8.0⁻	19.6	25.5	5.0
CN1424-9	16.9	30.0	12.6⁻	16.7	19.1	26.0	5.0
CN1345-8	21.8	25.9	15.0⁻	13.6	19.1	33.6	6.4
CN1407-8	15.4	51.3	14.4⁻	9.8	22.7	29.8	6.8
CN1423-557	21.5	31.6⁻	9.1⁻	9.8	18.0	32.2	5.8
CN1309-18	34.2*	74.7	9.0⁻	15.6	33.4	25.2	8.4
CN1423-215	26.1	46.5	7.8⁻	14.7	23.8	26.2	6.2
CN1388-7	1.2⁻	41.9⁻	18.1	14.1	18.8	32.5	6.1
CN1346-9	13.8	44.2⁻	17.8	13.3	22.3	31.8	7.1
CN1310-23	17.4	58.0	9.2	17.8	25.6	25.8	6.6
CN1108-13	12.9	37.4	21.8	13.4	21.4	24.8	5.3
AIS35-2	15.0	30.5	10.9	7.8	16.1	25.9	4.2
CN1038-16	14.6	52.6	9.9	17.2	23.6	26.1	6.2
I981	22.3	22.9	23.6	20.2	22.3	28.9	6.4

[z]Marketable yield:
* = Significantly higher than the superior control cultivar in the same group at p = 0.05.
– = Significantly lower than the superior control cultivar in the same group at p = 0.05.

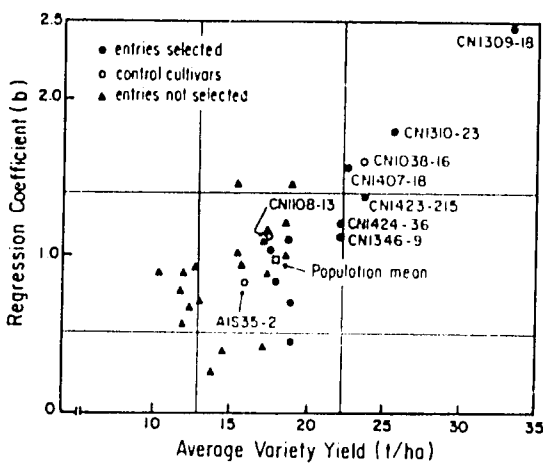


Fig. 3.
Relationship between average variety yield and stability of 33 sweet potato breeding lines grown in four environments in the wet and dry seasons from 1983 to 1984.

Conclusion

Clones selected in 1983 were found to be less promising than those selected in 1982. It appeared that the population was approaching a yield plateau around 20 to 30 t/ha in the wet season and 30 to 40 t/ha in the dry season. Our program should either find ways to break the yield barrier or emphasize more on improving specific characters, such as disease or insect resistance, and quality for different uses.

Yield Stability in Multi-Locational Trials

Introduction

Multi-locational yield trials were initiated during the 1983 wet season to study the yield stability of AVRDC breeding lines under a wide range of environments. The measurement

of yield stability is one of the most important and difficult tasks of the international breeding programs. This work is particularly difficult for sweet potato, as quarantine regulations are often rigid on entry of vegetatively propagated materials. In order to understand better the nature of yield stability and performance of AVRDC breeding materials under different environments, multi-locational trials were, therefore, conducted during the dry and wet seasons under nine different environments in 1983 and 1984.

Materials and Methods

Fifteen breeding lines and three control cultivars were evaluated during the wet and dry seasons from 1983 to 1984. The wet-season trials were conducted in six locations (Suilin, AVRDC, Shalu, Taoyuan, Taitung, and Penghu) and the dry-season trials were carried out in three locations (AVRDC, Taipou, and Taoyuan) in Taiwan. The summarized list of experimental designs and the experimental duration of all trials in both seasons are listed in Table 9.

Plots were spaced 1 m apart and arranged in a randomized complete block design. Fertilizer was applied at the rate of 40, 60, and 160 kg/ha for N, P_2O_5, and K_2O, respectively. Stability analysis followed the regression methods described by Finlay and Wilkinson (1963), Eberhart and Russell (1966), and Langer, Frey, and Bailey (1979).* As entries in the wet-season trials were slightly different from those in the dry-season trials, only nine trials with the same entries were included in the combined analysis.

Results

Table 10 summarizes the marketable root yields, dry matter contents, and dry matter yields of the 18 cultivars grown in nine different environments. The mean yield in different locations ranged from 10.3 t/ha to 32.4 t/ha with the wet-season trial in Suilin representing the poorest environment and the dry-season trial in Taipou, the most favorable environment. The wide range of environments provided an excellent opportunity to measure yield stability. Eight entries had mean yields across environments greater than 20 t/ha. All control cultivars yielded less than 20 t/ha.

In the stabiliy analysis, all four high-yielding lines had high regression coefficients, implying that they tended to perform well only under favorable conditions (Table 11).

Table 9. Summarized list of multi-locational trials during 1983-1984.

Location	Season	No. of Entries	No. of Replicates	Plot Size (m^2)	Transplanting Date	Harvesting Date
Suilin	summer	18	2	10	04-12-83	09-14-83
Penghu	"	18	2	10	05-03-83	10-03-83
Taoyuan	"	18	2	10	05-17-83	10-18-83
Taichung	"	18	2	10	05-20-83	10-19-83
Taitung	"	18	2	10	05-24-83	10-27-83
AVRDC	"	18	2	10	06-14-83	11-11-83
Taipou	fall	18	2	10	09-14-83	02-10-84
AVRDC	"	18	2	10	08-15-83	01-08-84
Taoyuan	"	18	2	10	08-02-83	12-16-83

* Eberhart, S.A and W.A Russell, 1966 Stability parameters for comparing varieties. Crops Science 6: 36-40.

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

Langer, I., K.J Frey, and J Bailey, 1979 Associations among productivity, production response, and stability indexes in OAT varieties. Euphytica 28: 17-24.

Table 10. Marketable root yield, dry matter, and dry matter yield of sweet potato selections in multi-location trials (nine environments) during the wet and dry seasons in 1983.

AVRDC Sel. No./ Variety Name	Wet Season						Dry Season			Mean Yield[z]	Mean DM[y]	Mean DM Yield
	$AVRDC_1$	Shalu	Taoyuan	Taitung	Penghu	Sulin	$AVRDC_2$	Taipou	Taoyuan			
CN1108-13	17.10	24.4	42.2	30.9	19.3	16.0	28.2	44.9	14.9	26.4*	24.4	6.4
CN1028-15	13.10	34.3	44.4	50.0	30.6	21.0	20.3	46.3	22.1	31.3*	23.6	7.4
CN1038-16	10.2	21.2	17.4	41.5	16.7	14.9	18.9	22.1	14.1	19.7	27.6	5.4
CN942-47	20.3	21.8	34.8	29.6	15.3	14.5	18.5	34.7	21.2	23.4	24.5	5.7
CN1058-10	12.4	26.4	28.6	26.8	20.0	16.4	18.4	31.8	18.8	22.1	21.8	4.8
CN1216-10	7.7	21.1	19.5	28.1	15.8	7.3	19.9	44.2	12.9	19.6	28.6	5.6
CN1219-1	9.7	20.0	29.2	25.9	15.8	2.8	19.9	29.5	26.6	19.9	28.5	5.7
CN1221-1	10.4	20.9	18.3	19.7	10.7	6.4	16.6	20.4	9.7	14.8	35.3	5.2
CN1229-2	8.6	18.7	18.3	21.8	17.0	7.9	19.4	27.1	15.3	17.1	32.1	5.5
CN1229-14	3.5	18.4	17.0	17.3	12.5	10.4	14.0	30.4	19.4	15.9	31.4	5.0
CN1280-3	7.3	22.1	29.1	19.0	13.2	9.4	31.1	36.8	27.4	21.7	28.6	6.2
CN1229-16	9.0	21.2	24.4	22.1	14.5	9.8	17.4	21.3	17.6	17.5	33.7	5.9
CN1280-4	2.3	5.8	12.3	9.5	1.4	0.8	2.3	11.8	17.6	7.1	28.6	2.0
CN941-32	15.1	27.1	23.7	43.5	22.6	8.6	27.5	51.5	22.0	26.9*	24.7	6.7
CN1232-9	12.8	29.2	39.2	30.8	27.4	10.9	18.5	36.6	15.9	24.6*	27.0	6.6
AIS35-2 (Ck1)	12.4	16.2	25.6	20.5	15.1	8.5	15.6	26.4	15.7	17.3	24.8	4.3
AIS0122-2(Ck2)	8.9	12.1	29.6	26.4	14.2	11.8	18.5	37.5	15.1	19.3	19.3	3.7
I57 (Ck3)	14.7	20.6	30.6	19.1	14.1	8.1	20.8	30.3	18.5	19.6	26.6	5.2
Mean	10.9	21.2	26.9	26.8	16.4	10.3	19.2	32.4	18.0	20.2	27.3	5.4
CV (%)	27.0	14.3	26.0	21.9	18.4	15.8	26.0	24.6	25.8	25.5	–	–

[z]Mean yield. * = significantly higher than that of the superior control cultivar at P = 0.05. [y]Dry matter.

Table 11. Mean yield, regression response index (b), coefficient of determination (r^2), mean square due to deviation from regression (S^2d) for 18 sweet potato cultivars grown in nine environments in the wet and dry seasons of 1983.

Entry	Mean Yield (t/ha)	b	r^2	S^2d	Entry	Mean Yield (t/ha)	b	r^2	S^2d
V2,CN1028-15	31.3	1.58	0.80	40.7	V17,TN57	19.6	0.87	0.78	13.4
V16,CN941-32	26.9	1.57	0.79	41.4	V7,AIS0122-2	19.3	1.19	0.85	16.0
V1,CN1108-13	26.4	1.35	0.81	26.7	V14,CN1229-16	17.5	0.66	0.81	6.2
V18,CN1232-9	24.6	1.24	0.78	26.2	V6,AIS35-2	17.3	0.75	0.91	3.5
V4,CN942-47	23.3	0.93	0.79	14.4	V11,CN1229-2	17.1	0.76	0.87	5.5
V5,CN1058-10	22.1	0.80	0.89	5.0	V12,CN1229-14	15.9	0.84	0.73	16.6
V13,CN1280-3	21.7	1.09	0.63	45.2	V10,CN1221-1	14.8	0.63	0.73	9.3
V9,CN1219-1	19.9	1.09	0.79	20.5	V15,CN1280-4	7.1	0.49	0.37	25.5
V3,CN1038-16	19.6	0.72	0.36	59.0	Mean	20.2	–	–	–
V8,CN1216-10	19.6	1.40	0.84	24.1	LSD 5%	4.81	–	–	–

Some cultivars responded differently, such as the highest yielding line, CN1028-15 Although this cultivar had a high regression coefficient (1.58), it had an above-average yield in the low-yielding location of Suilin CN1028-15 appeared to be a good cultivar since it showed a high mean yield and yet performed better than the average under adverse environments.

Fig. 4 shows the relationship between the average variety yield and yield stability of the 18 entries tested. Most of the cultivars fell under the category of "average yield" and "average stability". Nearly all high-yielding cultivars were relatively unstable. Low-yielding lines tended to be more stable yielders in different environments. For example, the lowest yielding line, CN1280-4, with a regression coefficient (b) of 0.49 yielded poorly in nearly all environments.

In correlation analysis, the trials grown under the three high-yielding locations (Taipou, Taoyuan, and Taitung) gave the best correlation with the overall mean yield ($r^2 = 0.94$); on the other hand, the two low-yielding locations (AVRDC-wet and Suilin) correlated poorly with overall mean yield ($r^2 = 0.67$. The wet-season yields also correlated poorly with dry season yields ($r^2 = 0.46$, but correlated well with the overall mean yield ($r^2 = 0.92$).

Further stepwise regression analysis showed that trials conducted under favorable environments gave a better estimate of the overall performance of entries than those under poor environments. As sweet potato is usually grown in poor soils under relatively low-input conditions, it is important to select cultivars adapted to poor environments. A separate selection procedure may be necessary to select cultivars adapted to unfavorable environments.

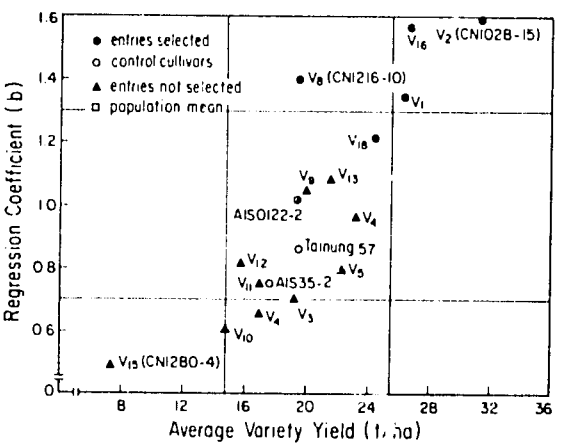


Fig. 4.
Relationship between average variety yield and stability of 18 sweet potato cultivars grown in nine environments in the wet and dry seasons of 1983.

Conclusion

Based on the 1983-84 trials, selections CN1028-15, CN1028-13, CN1232-9, and CN941-32 were identified as superior cultivars with an average marketable yield of more than 24 t/ha over nine environments. These selections were chosen for distribution to national programs for further adaptability tests.

High-yielding selections were usually less stable compared to the low-yielding ones. As it is difficult to select stable and high-yielding lines, efforts should be directed towards selecting lines that perform well in poor environments but have a relatively high overall mean yield.

Regional Yield Trial of Elite Sweet Potato Cultivars for Wet-Season Production in Taiwan

Introduction

The development of cultivars adapted to the hot-wet environment is one of the important objectives of the AVRDC sweet potato improvement program. In Taiwan, sweet potatoes are

grown during the cool-dry fall and winter seasons, since most of the local cultivars do not produce well under the hot-wet environments. According to the Taiwan Agricultural Year Book, the average yields of spring and summer sweet potato are only about 1/3 of the fall crop.

In order to solve the huge overproduction in rice and to reduce the import of field crops, the Taiwan Provincial Department of Agriculture and Forestry (PDAF) decided to conduct regional yield trials in cooperation with Taiwan Agricultural Research Institute (TARI) and AVRDC to identify superior cultivars of sweet potatoes for paddy fields in the wet-season. This project was started in the spring of 1984.

Materials and Methods

Six elite clones developed at AVRDC and Chiayi (TARI) and two check cultivars, TN64 and TN66, were evaluated in seven locations in Northern, Central, and Southern Taiwan in the spring and summer of 1984 (Table 12).

The randomized complete block design with six replications was used in all trials. Thirty-two plants (vine-tip cuttings) spaced 25 cm apart were planted in double rows on plots 16 m^2 in size. Basal fertilizer was applied at the rate of 30 kg N/ha, 60 kg P_2O_5/ha, and 90 kg K_2O/ha; an additional 30 kg N/ha and 90 kg K_2O/ha were side-dressed later.

Results

Table 13 shows the mean root yield, dry matter, protein, and starch contents of all entries in seven locations. The yields of three AVRDC selections, CN1108-13, CN1232-9, and

Table 12. Distribution, and planting and harvesting dates of the 1984 spring and summer regional yield trials.

Location	Planting Date	Harvesting Date	Growth Duration (Days)
Spring Trial:			
Taoyuan (Taoyuan DAIS)	03-30-84	09-06-84	160
Shalu (Taichung DAIS)	04-05-84	08-17-84	134
$AVRDC_1$ (Field No. 103)	03-22-84	08-30-84	160
Summer Trial:			
Kinshan (Taoyuan DAIS)	04-27-84	09-17-84	143
Penghu (Kaohsiung DAIS)	05-11-84	10-17-84	160
Ching Sui (Chiayi TARI)	06-14-84	10-26-84	134
$AVRDC_2$ (Field No. 34)	05-28-84	11-13-84	168

Table 13. Root yield and other yield components of elite sweet potato clones in regional yield trials in spring/summer 1984[z].

Entry Name	Root Yield(t/ha)		Dry Matter		Protein	Starch	Beta-carotene (mg/100g f.w.)
	Total	Market	percentage of dry weight	yield (t/ha)	percentage of dry weight	percentage of dry weight	
CN941-32	19.2	18.0e	28.6	5.5	1.6c	70.5ab	–
CN1108-13	26.0	23.2ab	30.8	8.0	1.5c	67.7bc	3.74
CN1232-9	24.2	22.3abcd	33.2	8.0	3.0a	63.6cd	–
CN1219-1	18.9	17.1e	33.5	6.3	2.0cb	45.6cd	–
CN942-47	24.1	22.6abc	31.3	7.5	2.1b	63.2d	7.92
63-74	20.3	19.1bcde	38.4	7.8	1.8cb	74.4a	–
TN64(check)	20.7	17.2e	32.1	6.6	2.1b	64.9cd	–
TN66(check)	25.4	23.8a	30.7	7.8	2.9a	64.4cd	5.35

[z]Mean of seven locations.

CN942-47, were not significantly different from the best yielding, newly released control cultivar TN66 and yielded significantly higher than control cultivar TN64. Only selection CN1232-9 had a protein content comparable to that of TN64. In starch content, selection CN941-32 and 63-74 were significantly higher than both controls.

In organoleptic evaluation, CN1108-13 was rated good to excellent and is considered promising for use as a staple or dessert cultivar. This selection has an orange flesh and contains 3.74 mg of beta-carotene in 100 g of fresh roots (Table 13).

Mean temperatures, cumulative precipitations, soil types, and precrops of the trials in each location are shown in Table 14. These environments provided an excellent opportunity to test the adaptability of the materials under hot-wet conditions.

Table 15 shows the marketable root yields of all entries in each location. In the spring trials under relatively cooler environments, CN942-47 was the highest yielder followed by CN1232-9 and TN66. In the summer trials, TN66 and CN1108-13 consistently outyielded other cultivars in all locations. In general, CN1108-13, TN66, and CN1232-9 performed comparatively well under both high and low rainfall conditions, showing better yield stability than others in the seven growing environments.

The parameters for estimating the yield stability of each entry are listed in Table 16. A stable cultivar is one that performs equally well under all environments and, theoretically, has the smallest possible regression coefficient (b), deviation from regression (S^2d), and the largest possible coefficient of determination (r^2).

CN1108-13 had a low regression coefficient and the lowest coefficient of determination. This selection is therefore relatively stable in yield across environments. The same is true for the highest yielding check, TN66. On marketable yield and adaptability, TN66 and CN1108-13 were comparable. The lowest yielding cultivar, CN1219-1, was also relatively stable, but did not respond to the increase in favorable conditions.

Except CN1232-9, none of the other entries with average yields showed low stability when the regression coefficient was plotted against average yield (Fig. 5). All selections thus responded positively to favorable environments.

Conclusion

In a series of 1984 wet-season trials, selections CN1108-13, CN1232-9, and CN942-47 were identified as superior than the control cultivar TN64. They exhibited similar levels of adaptability to the wet environments in Taiwan as the other control cultivar, TN66. By analyzing the stability parameters, selections CN1108-13, CN1232-9, and TN66 were shown to have relatively stable yields under both favorable and adverse environments. Trials will be continued in 1985 to identify the most superior entries for the spring and summer plantings in Taiwan.

Selection of Cultivars for Animal Feed and Starch Production

Introduction

As a traditional crop adapted to the tropical environment and familiar to the farmers, sweet potato has the potential to play a more important role as a major nutrition or energy source in the tropics. The development of cultivars suitable for feed and industrial uses would have great value for the tropical countries. This project is aimed at developing tropical cultivars with superior dry matter and starch yields, and better feed utilization efficiency.

This project has three major components. Cultivars with high dry-matter yields were selected for yield and adaptability test by the plant breeders. The selected entries were then evaluated by the chemists for nutritional analysis, digestibility bioassay, and starch determination. The final hog feeding-efficiency test is being conducted in cooperation with the Taiwan Livestock Research Institute. Only the breeding activity is presented in this report.

Table 14. Growing environment of elite sweet potato clones in the regional yield trials of the 1984 spring and summer seasons.

Season	Location	Duration (days)	Total Rainfall (mm)	Temperature (°C)			Soil Type	Precrop
				max.	min.	mean		
Spring	Taoyuan	160	1,564.1	32.3	19.4	25.8	sandy loam	rice
	Shalu	134	976.1	33.0	20.0	26.5	sandy clay loam	sweet potato
	$AVRDC_1$	160	1,434.8	29.7	21.9	25.8	sandy loam	mungbean
Summer	Kinshan	143	1,606.6	31.5	22.1	26.8	sandy loam	rice
	Penghu	160	473.1	33.2	24.0	28.6	clay loam	sweet potato
	Ching Sui	134	555.9	33.8	22.2	28.0	sandy clay loam	sugar cane
	$AVRDC_2$	168	1,418.31	30.3	22.8	26.6	sandy loam	tomato
Mean		151	1,147.0	32.0	21.8	26.9		

Table 15. Marketable root weight of elite sweet potato clones in the regional yield trial of the 1984 spring and summer seasons[z].

Entry Name	Marketable Root Weight (t/ha)									grand mean
	spring trial				summer trial					
	Taoyuan	Shalu	AVRDC1	mean	Kinshan	Penghu	Ching Sui	AVRDC2	mean	
CN941-32	39.4a	21.3cd	16.3c	25.7	16.3e	6.6c	9.4d	16.5	12.3	18.0
CN1108-13	31.1bc	24.9bc	24.2b	26.7	32.5a	12.6a	20.6ab	16.3	20.5	23.2
CN1232-9	31.6bc	30.8a	25.9ab	29.4	23.9b	6.5c	18.1bc	19.0	16.9	22.3
CN1219-1	28.5dc	17.7d	15.7c	20.6	21.3cd	5.4c	16.9bc	14.4	14.5	17.1
CN942-47	35.2ab	26.9ab	32.9a	31.7	19.2d	6.5c	18.0bc	19.8	15.9	22.6
63-74[y]	27.0dc	20.8cd	27.9ab	25.2	15.8e	9.7b	16.0c	16.3	14.4	19.1
Tainung 64[x]	23.6d	23.4bc	25.4ab	14.1	22.0bc	5.1c	6.6d	14.0	11.9	17.2
Tainung 66[x]	34.7ab	22.6bc	23.7b	27.0	32.1a	12.2a	22.1a	19.4	21.4	23.8
Mean	31.4	23.5	24.0	26.3	22.9	8.1	16.0	17.0	16.0	20.4
LSD 5%	–	–	–	–	–	–	–	–	–	4.327
CV (%)	14.2	14.8	25.6	–	8.3	25.0	19.2	22.7	–	–

[z]Any two means having a common letter are not significantly different at the 5% level, Duncan's Multiple Range Test. [y]Breeding line developed at Chiayi TARI.
[x]Check cultivars developed at Chiayi TARI.

Table 16. Mean yield, regression response index (b), and coefficient of determination (r^2) for eight elite sweet potato clones grown in eight environments in spring and summer of 1984.

Variety/ Selection	Mean Yield (t/ha)	b	r^2	S^2d
1 CN941-32	18.0	1.26	0.78	30.2
2 CN1108-13	23.2	0.86	0.76	15.1
3 CN1232-9	22.2	1.11	0.91	8.0
4 CN1219-1	17.1	0.86	0.84	9.4
5 CN942-47	22.6	1.22	0.86	16.2
6 63-74	19.1	0.76	0.75	13.0
7 Tainung 64	17.2	1.02	0.78	18.8
8 Tainung 66	23.8	0.91	0.79	14.2
Mean	20.4	1.00	0.81	15.4
LSD (%)	4.327	–	–	–

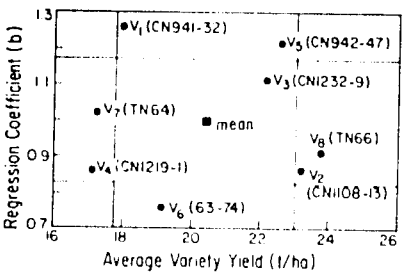


Fig. 5.
Relationship between the average variety yield and stability of eight elite sweet potato clones grown in seven locations in the spring and summer of 1984.

Materials and Methods

For the preliminary yield trial, 13 AVRDC selections with superior dry matter content and dry matter production were selected from previous trials and evaluated against the two leading Taiwanese starch/feed cultivars, Tainan 18 and Tainung New 31, under favorable environments in the winter of 1983. Plot size was 20 m^2 (80 plants) arranged in two rows in a randomized complete block design with two replications.

In the wet-season adaptability test, four promising entries selected from preliminary trials were planted again from June 28 to December 3, 1984 to evaluate their performance under hot-humid environment. A randomized complete block design with five replications was used in this trial. The same control cultivars were used.

Results

Table 17 shows the performance of all entries in the preliminary trial during the 1983 winter season. Two cultivars, CN1232-9 and CN1280-3, significantly outyielded the control cultivars. Seven AVRDC selections produced significantly higher dry matter yields than the control cultivars. Ten selections had higher percentages of extractable starch and actual extractable starch than the control cultivars. These selections have a good potential for use as either feed or starch extract in Taiwan under favorable environments.

In the summer adaptability test, all the AVRDC and Chiayi selections outyielded the two controls significantly (Table 18). Except CN1028-15 and CN941-32, three selections had higher starch percentages than the controls. Apparently, these two control cultivars are not adapted to the hot-humid environment.

Table 17. Selected high-starch breeding lines in a preliminary yield trial in 1983 fall[z].

Entry	Grade	Appearance	Uniformity	MKT Yield	DM[y]	DMY[x]	Extractable starch (%)	Extractable starch yield (t/ha)
CN1232-9	A	F-G	F-G	23.9*	33.4	7.28*	18.6	4.1
CN1280-3	A	F-G	F-G	27.0*	34.6	8.02*	18.0	4.9
CN1424NL-18	A	G	G	20.2	40.9	7.50*	21.4	4.3
CN1345-8	A	F	F	21.9	32.0	7.99*	15.3	3.4
CN1388-7	B	P	P	21.5	34.0	7.79*	18.5	4.0
CN1221-1	B	F-G	F	16.9	41.5	6.87	25.0	4.2
CN1216-10	B	F	G	16.1	34.4	5.11	17.2	2.8
CN1219-1	B	F	F	22.1	28.2	7.00	13.7	3.0
CN1229-2	C	P-F	F	19.0	35.5	6.73	20.2	3.8
CN1306-22	C	F-G	F-G	17.0	–	–	–	–
CN1229-14	C	P-F	P-F	20.8	34.2	7.29*	22.6	4.3
CN1423-153	C	G	G	19.1	40.1	7.20*	23.6	4.7
CN1330-11	C	F-G	F-G	19.9	29.4	0.42	23.6	4.7
Tainan 18[w]	–	F	F	12.0	28.2	3.46	15.4	1.8
Tainung New 31[w]	–	P-F	F	19.7	28.2	5.53	15.5	3.1

[z] Selected from 29 entries, transplanted on Nov. 16, 1983, harvested on May 18, 1984; replicated two times.

* = significantly higher than Tainung New 31 (control cultivar) at p = 0.05 in the same trial.

[y]Dry matter [x]Dry matter yield. [w]Local control cultivars for starch production.

Table 18. Performance of high-starch lines in the 1984 advanced yield trial in summer[z].

Entry	Appearance	Uniformity	Marketable Yield (t/ha)	Total Yield (t/ha)	Starch (%) (FW basis)	Starch Yield (t/ha)
CN1028-15	P-F	F	26.9*	27.5*	11.3	2.8
CN1232-9	G	G	22.9	23.5	20.5	4.8
CN1219-1	G	G	22.6	23.6	18.6	4.4
CN941-32	F	F-G	20.6	21.1	13.7	2.9
63-74	G	G	20.4	21.4	18.2	3.9
Tainan 17[y]	F	G	18.8	19.8	–	–
Tainan 18[y]	F	G	3.5	3.9	15.4	0.6
Tainung New 31[y]	F	F	4.9	5.6	17.5	1.0

[z]Transplanted on June 28, 1983 and harvested on Dec. 3, 1984; replicated five times. [y]Local control cultivars for starch production.

Conclusion

Two AVRDC selections showed excellent adaptability and starch yield under the hot-wet environment. In addition, two other selections gave superior yield and feeding quality for use as animal feed. These materials should be useful in tropical countries. Feeding efficiency tests and further adaptation trials in cooperating countries will be continued in the future.

Germplasm Collection

In 1984, eight sweet potato cultivars and 4,050 true seeds were introduced from Thailand, the Philippines, Indonesia, Taiwan, and the USA (Table 19). The total sweet potato collection

at AVRDC is now 1,208. Six of the eight new introductions were reported to be resistant to sweet potato scab, and the seeds introduced from the USA were taken from populations developed for weevil resistance. These materials will be used in the breeding program for scab and weevil resistance.

Table 19. List of AVRDC sweet potato introductions in 1984[z].

Source	Material	Number
Thailand	clone	2
Philippines	"	1
Indonesia	"	3
Taiwan	"	2
USA	seed	4050

[z]Introduced from January to December 1984.

Germplasm Evaluation

Introduction

Three hundred sixty-three accessions were introduced in 1983. These clones were multiplied and the established entries, including some old accessions, were characterized and evaluated from 1983 to 1984.

Materials and Methods

A total of 396 accessions and three check cultivars were grown in the dry season from September 29, 1983 to March 13, 1984 (166 days) at AVRDC. Plot size was 1.25 m^2 with five plants to each plot. Trials were not replicated but three check cultivars were planted every 40 entries for comparison. Morphological and horticultural characteristics were recorded according to the IBPGR descriptor list and AVRDC evaluation procedures. Six mature roots per entry were taken as samples for chemical analysis. Although yield data were also taken, these were viewed only as reference, since plot size was very small. These materials were also screened by the entomologist for resistance to sweet potato weevil and stem borers. Only the horticultural evaluation part is presented here.

Results

The distribution of marketable yield of 396 entries is shown in Fig 6. Yields ranged from 0 to 104 t/ha with a mean of 19.7 t/ha. (Note: the mean yield of the three control cultivars was 49.3 t/ha). Dry matter contents ranged from 17.7% to 42.2%, and starch yields from 0.1 to 14.1 t/ha. Some of the cultivars showed excellent starch and dry matter contents. Of special interest is the performance of cultivars introduced from the following countries which are described as follows:

IITA (Nigeria). In general, IITA materials were high in dry matter content (26.2 to 38.4%), with medium-level yields under AVRDC conditions (Table 20). Among the tested cultivars TIS2498, TIB1487, and TIS1499 seemed to have higher yield potential than others. The two orange-fleshed cultivars, TIB4 and TIS2544, were low-yielding, but had better root appearance and uniformity.

USA. Among the eight W-lines from Dr. Alfred Jones of the US Vegetable Laboratory, W149 and W154 had yield potential comparable to the three control cultivars (Table 21). W-lines tended to have low dry matter (22.9 to 27.9%), with good shape and uniformity. All of these materials are orange-fleshed.

Puerto Rico. Table 22 shows the performance of eight cultivars from Dr. Franklin Martin of Puerto Rico. These materials had good dry matter content (26.1 to 33.3%) and yielded moderately under AVRDC conditions. Most clones are white or yellow-fleshed, except Trompo Negro whose flesh is dark purple. The sugar contents of line 99 and the local starch cultivar, Tainan 18, were comparable.

Japan. In general, Japanese cultivars were found to be excellent in dry matter content but relatively low-yielding under AVRDC conditions (Table 23). Most had excellent taste and

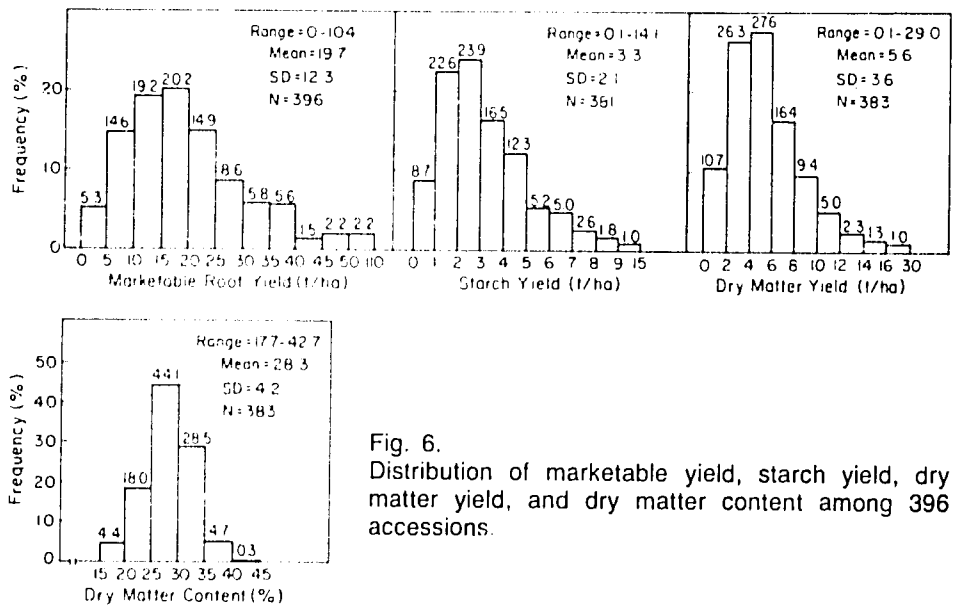


Fig. 6.
Distribution of marketable yield, starch yield, dry matter yield, and dry matter content among 396 accessions.

Table 20. Performance of sweet potato cultivars from IITA (Nigeria) during the 1983-84 dry season at AVRDC.[z]

Acc. No.	Variety Name	Marketable Yield (kg/plant)	Dry Matter (%)	General Appearance[y]	Root Uniformity[y]	Flesh Color[x]	Origin
1947	TIB4	0.6	32.2	G	G	O5	IITA/
1948	TIS1487	1.1	31.1	F	F	Y1	"
1949	TIS2498	1.2	32.7	F	F	Y1	"
1950	TIS1499	1.0	26.2	F	F	W	"
1951	TIS3017	0.5	33.9	F	F	Y1	"
1952	TIB10	0.6	37.8	F	F	Y2	"
1953	TIB2	0.6	38.4	F	F	Y1	"
1954	TIB	0.5	36.1	F	P	Y1	"
1955	TIS2532	0.6	30.4	F	G	Y1	"
1956	TIS2544	0.3	30.5	G	G	O4	"
1424	Tainan 18(Ck1)	1.4	27.6	F	F	Y3	Taiwan
1981	Tainung 66(Ck2)	1.0	28.1	F	G	O5Y5	"
	CN1038-16(Ck3)	1.3	27.0	F	F	Y3P1	AVRDC
Population mean[w]		0.5	28.3				

[z] Transplanted on Sept. 29, 1983 and harvested on March 13, 1984 (166 days), plot size = 1.25 m² (five plants per plot)

[y] G = good, F = fair

[x] O4 = moderately orange, O5 = deep orange, Y1 = nearly white, Y2 = very pale yellow, Y3 = light yellow; W = white, O5Y5 = deep orange with yellow tinge, Y3P1 = light yellow with purple tinge

[w] Means of 383 entries evaluated in the same trial

flavor. Some of these materials are now being used as parents in the hybridization program to improve dry matter content and taste. The famous Japanese cultivars, Kokei 14, Beniaka, and Koganesengau, yielded very low in this trial.

Korea, Philippines, and Indonesia. Table 24 shows the performance and characteristics of the cultivars introduced from these countries. Compared with the Japanese cultivars, the

Table 21. Performance of sweet potato cultivars from the US during the 1983-84 dry season at AVRDC.[z]

Acc. No.	Variety Name	Marketable Yield (kg/plant)	Dry Matter (%)	General Appearance[y]	Root Uniformity[y]	Flesh Color[x]	Origin
I957	W-13	0.3	27.9	G	G	O4	Dr. Alfred
I958	W-71	0.4	27.2	G	G	O6	Jones US
I959	W-115	0.4	27.1	F	P	O6	Veg. Lab
I960	W-125	0.9	26.1	G	G	O4	USA
I961	W-149	1.6	23.2	G	F	O5	USA
I962	W-152	0.7	22.8	F	F	O3	USA
I963	W-154	1.2	22.9	G	G	06	USA
I964	W-178	0.3	27.2	F	F	O5	USA
I424(Ck1)	Tainan 18	1.4	27.6	F	F	Y3	Taiwan
I981(Ck2)	Tainung 66	1.0	28.1	F	G	O5Y5	Taiwan
	CN1038-16(Ck3)	1.3	27.0	F	F	Y3P1	AVRDC
Population mean[w]		0.5	28.3				

[z] Transplanted on Sept. 29, 1983 and harvested on March 13, 1984 (166 days), plot size = 1.25 m^2 (five plants per plot)

[y] G = good, F = fair

[x] O3 = light orange, O4 = orange, O5 = nearly deep orange, O6 = deep orange, Y3 = light yellow; O5Y5 = nearly deep orange with yellow tinge, Y3P1 = light yellow with purple tinge.

[w] Means of 383 entries evaluated in the same trial

Table 22. Performance of sweet potato cultivars from Puerto Rico during the 1983-84 dry season at AVRDC.[z]

Acc. No.	Variety Name	Marketable Yield (kg/plant)	Dry Matter (%)	General Appearance[y]	Root Uniformity[y]	Flesh Color[x]	Origin
I1192	99	0.9	29.7	F	F	Y1	Dr. Franklin Martin Puerto Rico
I1193	Trompo Negro	0.8	32.3	G	G	Y2P7	"
I1194	Hes 50	0.8	31.2	G	G	Y2	"
I1195	Hes 54	0.2	33.3	F	F	Y2	"
I1196	Hes 33	1.0	28.5	F	F	Y1	"
I1197	Hes 34	0.6	32.8	F	F	Y2	"
I1198	Hes 35	1.0	26.1	P	P	W	"
I1199	Puerto Rico local CV II	0.9	31.7	F	F	Y2	"
I424(Ck1)	Tainan 18	1.4	27.6	F	F	Y3	"
I981(Ck2)	Tainung 66	1.0	28.1	F	G	O5Y5	"
	CN1038-16(Ck3)	1.3	27.0	F	F	Y3P1	"
Population mean[w]		0.5	28.3				

[z] Transplanted on Sept. 29, 1983 and harvested on March 13, 1984 (166 days), plot size = 1.25 m^2 (five plants)

[y] G = good, F = fair

[x] Y1 = nearly white, Y2 = very pale yellow, Y3 = light yellow, W = white, Y2P7 = very pale yellow with deep purple, Y3P1 = light yellow with purple tinge, O5Y5 = deep orange with yellow tinge.

[w] Means of 383 entries evaluated in the same trial

three white-fleshed Korean selections showed better yield potential with acceptable dry matter contents.

Cultivars developed by Dr. Saladaga in the Philippines also showed good yield potential and acceptable dry matter content. They are now being used in the hybridization program for resistance to sweet potato scab.

Three of the Indonesian cultivars also yielded well. The cultivar Daya is also being used for tolerance to weevil in our program. The seeds will be sent back to Dr. Soenaryo in Indonesia for selection.

Conclusion

Of the 396 accessions evaluated, 21 were identified to have high dry matter content (35 to 42.7%), with Kyushu 29 and Kyushu 48 from Japan, and TIB2 from IITA as the outstanding cultivars. Twenty-two cultivars showed superior dry matter yield potential, with Kinmen 18, TIS2498, Simi, W149, and HES35 among the top; 28 showed excellent protein content (9.1 to 13%); and 17 indicated good total biological yield (vine plus roots). These materials will be evaluated further in separate trials to verify their outstanding characteristics. Cultivars showing superior yields will also be tested in replicated trials for adaptation to the hot-wet season.

Table 23. Performance of sweet potato cultivars from Japan during the 1983-84 dry season at AVRDC.[z]

Acc No.	Variety Name	Marketable Yield (kg/plant)	Dry Matter (%)	General Appearance[y]	Root Uniformity[y]	Flesh Color[x]	Origin
674	Shiichifuk	0.4	36.1	F	F	Y1	Dr. I. Tanabe Japan
675	Naeshirax	0.6	30.3	P	P	Y1	"
676	Kokei	0.3	32.0	F	F	Y1	"
677	Tsuruna Shige-Nji	0.1	33.8	P	P	Y2	"
678	Hayato-Imo	0.3	29.0	P	P	O2	"
679	Beniaka	0.2	32.0	F	F	Y2	"
965	Kyushu 48	0.6	39.1	F	G	Y2	Kyushu National Agr. Expt. Sta. Japan
966	Tsukumoaka	1.0	28.9	F	F	Y1P2	
967	Kyushu 59	0.2	42.7	P	P	Y1	"
968	Kyukei 7492-2	0.7	34.9	F	F	Y1	"
969	Koganesengau	0.6	37.2	F	F	Y2	"
970	Minamoyutaka	0.4	33.9	F	F	Y2	"
976	F53-6	0.6	34.9	F	P	Y2	"
977	Kyukei 17-3028	0.5	29.2	F	G	W	"
978	FV 62-41	0.3	33.3	F	F	Y2	"
979	Tinian	0.9	32.3	F	F	Y1	"
1424	Tainan 18 (Ck1)	1.4	27.6	F	F	Y3	Taiwan
1981	Tainung 66 (Ck2)	1.0	28.1	F	G	O5Y5	Taiwan
	CN1038-16 (Ck3)	1.3	27.0	F	F	Y3P1	AVRDC
Population mean[w]		0.5	28.3				

[z] Transplanted on [illegible] and harvested on March 13, 1984 (166 days), plot size = 1.25 m^2 five plants

[y] F = fair, P = poor

[x] Y1 = nearly white with very pale yellow, Y3 = light yellow, W = white, O2 = very light orange; Y1P2 = nearly white with very light purple, Y3P1 = light yellow with purple tinge, O5Y5 = deep orange with yellow tinge

[w] Means of 365 entries evaluated in the same trial

Table 24. Performance of sweet potato cultivars from Indonesia, Philippines, and Korea during the 1983-84 dry season at AVRDC.[z]

Acc. No.	Variety Name	Marketable Yield (kg/plant)	Dry Matter (%)	General Appearance[y]	Root Uniformity[z]	Flesh Color[x]	Origin
I1166	Hong-Mi	1.2	28.0	G	G	Y1	Korea
I1167	Sin-Mi	1.4	27.9	F	F	Y1	"
I1168	Huang-Mi	0.1	24.8	P	P	Y1	"
I1173	V2-1	0.9	25.4	F	P	O3	Dr. Saladaga Philippines
I1174	V2-3	1.1	27.3	F	F	Y2O1	"
I1175	V2-30	0.8	28.3	F	F	Y4O1	"
I1179	No. Kode: 4 Klon: I12-37	0 8	29.9	F	P	Y1	Indonesia
I1182	No. Kode: 37 Klon: 17-5	1.0	28.4	F	F	Y3	"
I1183	2 Ind	1.2	26.0	F	F	Y1O1	"
I1186	Daya	0.4	25.6	F	F	Y1O1	"
I424(Ck1)	Tainan 18	1.4	27.6	F	F	Y3	Taiwan
I981(Ck2)	Tainung 66	1.0	28.1	F	G	O5Y5	"
-	CN1038-16(Ck3)	1.3	27.0	F	F	Y3P1	AVRDC
Population mean[w]		0.5	28.3	-	-	-	-

[z] Transplanted on Sept. 29, 1983 and harvested on March 13, 1984 (166 days), plot size = 12.5 m^2 (five plants per plot)

[y] G = good, F = fair

[x] Y1 = nearly white, Y3 = light yellow, O3 = light orange, Y1O1 = nearly white with pale orange; Y2O1 = very pale yellow with purple tinge, Y3P1 = light yellow with purple tinge, Y4O1 = moderately yellow with purple tinge, O5Y5 = deep orange with yellow tinge

[w] Means of 383 entries evaluated in the same trial

International Cooperation

Distribution

A total of 110 sets of sweet potato breeding lines and accessions were sent to 99 cooperators in 44 countries in 1984 (Table 25).

Most of the materials were sent in meristem-culture form. A new distribution system using small virus-free storage roots was developed at AVRDC to supplement the tissue-culture test-tube form as distribution materials. The new system is expected to expand the number of sweet potato samples distributed to the cooperators, and most importantly, to provide a safe, reliable, and efficient method for our international sweet potato testing projects. The new quarantine screenhouse funded by IBPGR will also be used to produce virus-free roots of the elite germplasm for distribution.

Variety Release in Tahiti

A number of AVRDC sweet potato selections were recently released to farmers in French Polynesia, as reported by Mr. Jean Louis Reboul of the IRAT/CERDAT Mission in Tahiti. Five of these AVRDC sweet potato selections, CN942-47, CN1038-16, CN1038-15, CI590-33, and CI591-14, were recommended to farmers because of their high yields, early maturity, and good eating quality. These selections yielded from 50 to 90 t/ha compared with 10 to 20 t/ha for most local cultivars in a four-month growing period in trials conducted for three seasons in Tahiti (Table 26).

In addition, the IRAT scientists successfully used the AVRDC germplasm as parental stocks to improve local cultivars. Seven breeding lines were selected by the IRAT scientists for their breeding program.

Currently, these superior selections are being multiplied in Tahiti and nearby islands for distribution to farmers. A catalog describing them was prepared by the IRAT scientists in Tahiti for the extension workers and interested persons in French Polynesia.

Philippines

Mr. Antonio R. Veloso, a former AVRDC training scholar from the Visayas State College of Agriculture (ViSCA), conducted a trial comparing nine cultivars from AVRDC against three control cultivars developed by the Philippine Root Crops Research and Training Center at Baybay, Leyte from April to August 1984. Three AVRDC clones outyielded the best control cultivar VSP-1 (Table 27). The ViSCA researchers were satisfied with the performance of AVRDC materials, particularly selection CN1232-9 which was recommended for human consumption because of its taste and appearance, and for feed or starch production.

Mr. Pedro C. Tobias, head of the Romualdez Experiment Station in Babatngon, Leyte, and also a former AVRDC training scholar, evaluated a series of AVRDC selections in 1983 and 1984. In the replicated trials conducted from March to July 1984, only a few AVRDC materials performed as well as the local check cultivars. Most of the AVRDC selections were reportedly susceptible to sweet potato scab, thus, reducing the yield. CI1139-17 which produced 28.5 t/ha of marketable roots compared to 23.9 t/ha of the superior check cultivar, Kabiti, appeared to be the only AVRDC clone tolerant to the scab disease (Table 28).

Table 25. List of AVRDC sweet potato selections sent to cooperators in 1984.

Area	No. of Country	No. of Package[7]
Asia	11	58
Africa	11	22
Americas	14	21
Oceania	7	8
Europe	1	1
Total	44	110

[7]Containing 42 cultivar/selection

Table 26. Yield, eating quality, and origin of the specially recommended sweet potato cultivars in French Polynesia.[7]

Selection No./ Cultivar Name	Pedigree	Origin	Year Introduced/ Collected	Yield (t/ha) 4th month	5th month	6th month	Eating Quality
CN942-47	B 6712 (OP)	AVRDC	1983	60	50-70	–	1
CN1028-15	PI344129/B6708(OP) //I57(OP)-4	AVRDC	1983	50	70-90	–	2
CN1038-16	PI344129//Red Tuber Tail/OK 6-3-118/// I57(OP)-4	AVRDC	1983	50	40-50	–	1
CI590-33	Poly I57(I)	AVRDC	1979	46	–	60	4-5
CI591-14	Poly I57(I)	AVRDC	1979	38	49	–	4
Au Marie Vareau	–	Pierrot Tuaiva	1969	–	12-15	15-32	1
Maareva	–	Tahiti	1981	–	15	20-50	1-2
Vehi	–	Tahiti	1981	–	25	20-30	1
N°7	Au Marie Vareau/ CI591-14	Tahiti (IRAT)	1981	–	15-35	–	1-2

[7]Source: J.L. Reboul, Taputuarai and R. Yau-Akui. 1984. Catalogue des principales varietes existant en polyesie Francaise. CERDAT/IRAT

In the Philippine highlands, Ms. Zenaida C. Nisperos and Ms. Ines C. Gonzales conducted trials to evaluate AVRDC and ViSCA selections during the dry season from November 1983 to May 1984. Among the AVRDC entries, AIS0122-2 was the most promising, being the second highest yielder in the trial (Table 29).

However, its percentage of marketable roots was quite low due to their irregular shape. CN1108-13 and CN1028-15 were also identified as promising in the same trial. The local cultivars were generally preferred to the AVRDC entries, except 1444, in taste. In addition, AVRDC materials CN1108-13, CN1038-16, and I-430 were reportedly susceptible to sweet potato scab.

Indonesia

Mr. Afriadi Laudin of the Sumatra Agricultural Research Institute for Food Crops (SARIF) in Padang, Indonesia, reported that clones selected from true seeds provided by AVRDC performed very well in replicated trials conducted in 1983. Four selections yielding

Table 27. Performance of AVRDC sweet potato selections and control cultivars in ViSCA, Philippines.[z]

Entry	Number of Plants	Total Root Weight/Plot (kg)	Root Yield (t/ha)	Origin
CN 941-32	19	4.5	7.5	AVRDC
CN 942-47	20	8.0	13.3	"
CN1028-15	19	12.0	20.0	"
CN1108-13	20	14.5	24.2	"
CN1229-16	20	8.7	14.5	"
CN1232-9	20	13.4	22.3	"
CN1308-1	19	6.5	10.8	"
I57	20	11.3	18.8	"
I981	19	17.0	28.3	"
VSP-1	20	12.4	20.7	ViSCA,
VSP-2	19	11.0	18.3	"
VSP-3	20	9.4	15.7	"

[z]Data provided by Antonio Rizalde Veloso, Visayas State College of Agriculture Philippines, plants transplanted on April 16, 1984 and harvested on Aug. 7, 1984.

Table 26. Performance of AVRDC sweet potato selections and control cultivars in Leyte, Philippines.[z]

Entry	Marketable Wt (t/ha)	Total Wt (t/ha)	Scab Rating
CI1088-11	15.8	16.6	5.5
CI953-22	13.5	15.6	1.5
CI1077-9	16.4	17.1	1.5
CI1098-5	12.9	13.4	6.5
CI983-4	15.4	15.7	6.75
CI1139-17	28.5	28.8	1.0
CI975-7	15.5	16.0	2.0
CI1124-4	14.9	14.9	6.0
LS27-12	11.6	11.9	2.5
BNAS 51(Ck1)	10.0	10.4	1.0
KABITI (Ck2)	23.9	25.9	1.0

[z]Data provided by Pedro C. Tobias, Romualdez Experiment Station, Babatngon, Leyte, Philippines, plants transplanted at Res-Babatngon, Leyte on March 22, 1984 and harvested on July 22, 1984, replicated four times.

from 29 to 37 t/ha significantly outyielded the local check cultivars, Daya and Racik Merah (Table 30). These lines were selected for the regional trials in 1984.

Crosses are being made between AVRDC lines and Indonesian scab-resistant cultivars at AVRDC. These seeds will be sent to Dr. R. Soenaryo at Bogor for further selections.

Thailand

Two trials were conducted at the AVRDC Thailand Outreach Station at Kamphaeng Saen. The first trial evaluated six cultivars from November 1983 to March 1984. AVRDC

Table 29. Performance of AVRDC/ViSCA sweet potato selections in the Philippine highland.[z]

Entry	Yield (t/ha)	Ave.No.of Roots Per Plant	Origin
AIS0122-2	59.2	7	AVRDC
CN1108-13	52.9	9	"
CN1028-15	51.6	5	"
I444	44.1	9	"
CN1038-16	38.7	5	"
I57	37.9	7	"
I430	34.9	7	"
V3-11	59.8	8	ViSCA,
V3-2	57.2	3	"
V2-72	54.4	10	"
V2-1(VSP1)	52.5	9	"
V2-47	50.0	7	"
V2-45	44.6	5	"
V2-30(VSP2)	38.7	6	"
V2-3(VSP3)	33.1	5	"
BNAS-51	31.0	4	"
Georgia Red	29.7	5	"
CPU #3	23.3	7	"
Kalbooy(Ck1)	57.6	6	highland, Philippines
Mabucag(Ck2)	19.8	4	"

[z]Data provided by Zenaida C. Nisperos, Mountain State Agricultural College, La Trinidad, Benguet, Philippines, plants transplanted on November 5, 1983 and harvested on May 16, 1984

Table 30. Preliminary yield trial of sweet potatoes in Indonesia.[z]

Entry	Yield (t/ha)	Harvesting Index(%)
17-5	20.4bc	47.9
I307(OP)-Sr-11	19.3bc	48.8
I307(OP)-Sr-118	22.5b	50.0
I307(OP)-Sr-129	18.0bc	54.5
CI688-24(OP)-Sr-129	15.4c	20.4
CI478-5(OP)-Sr-9	37.0a	64.6
I535(OP)-Sr-61	7.4c	41.5
CI916-46(OP)-Sr-11	29.3a	77.4
CI916-46(OP)-Sr-32	29.1a	59.1
CI478-6(OP)-Sr-2	29.8a	57.4
Racik merah (Ck1)	20.6bc	45.5
Daya (Ck2)	23.2b	56.1

[z]Data provided by Mr. Afriadi Laudin, SARIF, Padang, Indonesia, plants transplanted in March 1983 and harvested in Sept. 1983, replicated three times.

Selection AIS0122-2 was the second highest yielder in the trial. It outyielded the local cultivar Pakchong #3, but was inferior to Pakchong #9.

A second trial evaluated 12 AVRDC selections/accessions at the same time at TOP. Only selection CN1028-15 (17.3 t/ha) significantly outyielded the best local cultivar Ungbuay (12.4 t/ha). The taste of CN1028-15 was reported to be soggy and unacceptable.

Bangladesh

The Bangladesh Agricultural Research Institute evaluated 24 sweet potato cultivars introduced from various sources, including IITA, Philippines, and AVRDC in six different locations, to study their yield and quality. Five cultivars were selected for final evaluation on the basis of yield, weevil resistance, keeping quality, and beta-carotene content. Among them, AIS0122-2 was a possible candidate for release to the farmers owing to its high beta-carotene content, yield, and good appearance (Table 31).

Table 31. Performance of sweet potato cultivars in regional yield trials in Bangladesh.[z]

Entry	Yield (t/ha)	Beta-carotene (μg/100 g)	Weevil Damage (%)	Origin
B-BAS White[y]	40.9	612	27.5	Philippines
Cinjhi[y]	41.2	134	23.1	–
AIS0122-2[y]	36.6	6837	23.8	AVRDC
AIS209-3	34.0	7360	18.6	"
AIS243-2	35.8	252	8.8	"
AIS243-2-1	34.9	156	38.6	"
CI489-1	36.1	257	31.7	"
CI548-3	34.9	–	13.9	"
TIS3032	34.5	32.0	14.0	IITA, Nigeria
USA No. 1	40.7	125	11.02	USA
Tinirining[y]	41.0	515	16.4	–

[z]Data prepared by Mr. M.M. Rashid, Annual Report 1982-83, Bangladesh Agr. Res. Inst. Joydebpur, Bangladesh. [y]Entries selected for further trials.

Sweet Potato Entomology

Search for Germplasm Sources Resistant to Sweet Potato Weevil

Introduction

Sweet potato weevil, *Cylas formicarius formicarius* F (Coleoptera: curculionidae), is the most destructive pest of sweet potato in the tropics. The larvae and adults feed on sweet potato roots and crowns. Weevil feeding either in roots or stems does not reduce the yield, but the quality of infested roots is impaired even by slight pest damage. In order to control this insect cheaply and effectively, sweet potato germplasm has been screened since 1975 to identify sweet potato accessions resistant to this pest. Two tests were conducted during 1984.

Materials and Methods

Sweet potato accessions were planted between two weevil-source rows in a sweet potato weevil nursery where a susceptible cultivar was planted in source rows ten weeks earlier and was infested by releasing laboratory-reared weevils before transplanting the test materials. The crop was grown by traditional cultural practices, except that no insecticide was used. At harvest the roots were evaluated for weevil infestation by cutting open each root and counting the number of larvae, pupae, and adults inside. The damaged and healthy portions of each root were also separated, and by weighing the damaged part, damage percentage was calculated. Weevils feeding on the crown were also recorded. Insect count and root damage percentage data were statistically analyzed to select relatively less affected accessions in each test.

The Duncan's Multiple Range Test was used in the first screening which had a small number of entries. In the second screening where a large number of newly introduced accessions were screened, the mean number of insects (larvae + pupae + adults) per kilogram of roots and the mean percentage of damaged roots were subjected to statistical analysis based on mean and standard deviation (sd). The accessions that had insect number or damage percentage less than mean − 2sd were considered highly resistant (HR); between mean − 1sd to mean − 2sd, moderately resistant (MR); between mean and mean − 1sd, with low resistance (LR); between mean and mean + 2sd, susceptible (S); and more than mean + 2sd, highly susceptible (HS).

Results

First test. The 84 entries included in this test were selected from 1983 tests at Penghu where some of these accessions were least damaged and others did not give adequate yield. These entries were planted along with known susceptible checks in four replicate tests. Few entries that yielded less than 1 kg/plot were not evaluated. The results of weevil number and percentage of damaged roots of least damaged ones, along with one susceptible check, are summarized in Table 1. Eight accessions out of 58 evaluated showed considerably less weevils and damaged roots than the rest. Accession 1413 which was resistant in last year's test at

Table 1. Performance of selected sweet potato accession for resistance to sweet potato weevil.[z]

Accession No.	No. Weevils per kg Roots	Damaged Roots (%)	Yield (t/ha)
I207	2.2e	1.1lm	1.8
I228	0.0e	0.0m	3.2
I229	0.4e	1.3klm	2.9
I281	0.3e	2.2jklm	7.7
I306	0.9e	0.5m	2.1
I376	1.7e	1.5jklm	10.2
I407	0.0e	0.0m	2.3
I413	1.6e	1.9jklm	3.2
I117[y]	87.6d	33.6a	10.0

[z]Planting date: Oct. 12, 1983; harvest date: March 12, 1984; plot size: 5 m × 1 m. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test. [y]Susceptible check.

AVRDC was also resistant in this year's test. However, two entries, I152 and I416, which were among the least damaged in the 1983 AVRDC test, were susceptible in the 1984 test.

Since wide variations in weevil damage of the same accession is common in sweet potato, these eight accessions will be further screened to confirm resistance before including them in our resistance breeding program.

Second test. In the second test, we screened 549 newly received accessions from Papua New Guinea in a nonreplicated trial. At harvest the number of insects per kilogram of roots and the percentage of damaged roots were determined. There was a wide variation in weevil infestation. The number of weevils per kilogram of roots ranged from 0 to 386 and the percentage of root damage, from 0 to 38.6. Since a large number of entries fell under the resistant category, 56 accessions with no weevil damage were selected for multireplicate confirmatory screening in late 1984. The results of this test will be reported in 1985.

Second Screening of Selected Sweet Potato Accessions for Resistance to Sweet Potato Vine Borer at Penghu Island

Introduction

Sweet potato vine borer, *Omphisa anastomasalis* (Lepidoptera: Pyralidae) is a serious pest of sweet potato all over Asia, especially in semiarid regions. The larvae of this insect bore into the vines and feed concealed inside. At times they also attack roots, especially those closer to the soil surface. Their infestation of vines results in up to 50% yield loss. In 1981, we identified two accessions with a moderate level of resistance to this insect. These accessions are now being used in our resistance breeding program. In 1984, 43 accessions were screened, including two standard resistant and four known susceptible checks, for a second confirmation of their resistance. Thirty-seven of these accessions were less damaged in a test at Penghu island in 1983.

Material and Methods

A 0.3 ha piece of land was rototilled, applied with basal fertilizer, and worked into 1 m wide beds. These beds were further divided into 5 m long plots. Stem cuttings of each entry were planted as a single row on the top of the bed. Each accession had four replicates

arranged in a randomized complete block design. The crop was raised according to customary cultural practices, except that no insecticide was applied.

A week before the crop was to be harvested, each entry was observed for vine borer infestation. Vine borer infestation can be easily judged by the presence of adult escape holes at crown position and the presence of frass resulting from larval feeding activity within the stem. Such frass gets accumulated at crown position. As a consequence of larval feeding, vines, especially near the crown, become hollow.

Vine-borer-infested and total number of plants were recorded, and the damage data were converted to percentage of damaged plants for comparison. The mean percentage of damaged plants in each accession was compared by Duncan's Multiple Range Test.

Results

The results of the vine borer infestation are summarized in Table 2. The infestation ranged from 0 to 56% plants. Six accessions, including one standard resistant check, I92, were free of vine borer damage. One accession, I695, had only 1.4% plants damaged. In general insect population was low, thus, their distribution was not even; as a result, some accessions escape damage. For example, 12 accessions that had no damage in the 1983 tests suffered various levels of damage in this test. These seven accessions will, therefore, be evaluated at AVRDC with the release of laboratory-reared insects and again at Penghu in 1985.

Table 2. Infestation of selected sweet potato accessions by sweet potato vine borer.[z]

Accession No.	Damage (%)
I582	0.00i
I656	0.00i
I708	0.00i
I780	0.00i
I789	0.00i
I92[y]	0.00i
I695	1.38hi
AIS35-2[x]	38.88bc

[z]Data are means of four replicates. Means in each column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test. [y]Standard resistant check. [x]Standard susceptible check.

Sweet Potato Pathology

Survey of Sweet Potato Viruses in AVRDC Fields and Evaluation of the Survey Method

Introduction

In 1983, a survey of AVRDC sweet potato plantings was conducted for SPV-A. The symptoms commonly associated with SPV-A were chlorotic spots, red rings, and mottle. However, SPV-A was not always detected in leaves with these and other symptoms. Furthermore, symptomless leaves sometimes were also found to contain SPV-A. This was attributed to the presence of viruses other than SPV-A which might produce similar symptoms, or to an uneven distribution of SPV-A within the plant, or to both.

The first part of this assumption was tested by surveying AVRDC fields for both SPV-A and SPV-N, the other common sweet potato virus in Taiwan; the second part was tested by examining five plants showing prominent symptoms for the internal distribution of both viruses.

Materials and Methods

To survey for the presence of SPV-A and SPV-N in AVRDC fields, a total of 305 samples were collected in 1984 from plants with prominent virus symptoms. Of each plant, one leaf showing clear symptoms was homogenized (1:10) in ELISA extraction buffer and tested by ELISA using a dilution of 1:500 of conjugate and gamma-globulin for both SPV-A and SPV-N.

To determine the distribution of SPV-A and SPV-N within plants, four plants were chosen in which SPV-A, or SPV-A and SPV-N were previously detected. From each plant, all the leaves were collected and tested individually for the presence of each virus by ELISA, as described above. Stem pieces, 2 cm in length, from the base and the tip of each stem, and from the side branches were also examined.

Results

Of 305 field samples, 12 were found infected with SPV-A. SPV-N was detected in 86 of 251 samples tested. The symptoms associated with SPV-N were similar to those of SPV-A: chlorotic spots, purple spots, and purple rings. In this survey, neither SPV-A or SPV-N could be detected in all leaf samples showing symptoms. The presence of SPV-N in AVRDC fields may thus only account in part for the fact that in last year's survey SPV-A was not detected in all plants showing typical virus symptoms.

Testing individual leaves of plants for both viruses, however, clearly indicated that neither SPV-A nor SPV-N were evenly distributed within the plant. The viruses could not be detected in all leaves showing symptoms and were also found in symptomless leaves (Table 1). The percentage of leaves with SPV-A was found to be much higher than those with SPV-N.

Table 1. Incidence of SPV-A and SPV-N in individual leaves[z].

Symptom	Plant 1 (I-13)				Plant 2 (I-13)				Plant 3 (I-18)				Plant 4 (I-387)		
	T	A	N	A+N	T	A	N	A+N	T	A	N	A+N	T	A	N
1 No symptoms	59	21	2	2	18	13	4	4	125	23	11	6	93	22	0
2 Purple rings	5	3	0	0	10	8	6	6	–	–	–	–	7	4	0
3 Purple patches	19	6	0	0	25	17	21	13	39	5	3	2	11	4	0
4 Purple margin	8	1	1	0	14	6	1	1	–	–	–	–	–	–	–
5 Purpling	17	2	1	0	4	1	0	0	–	–	–	–	18	0	0
6 Chlorotic spots	99	59	4	3	6	2	0	0	88	12	13	5	8	0	0
7 Yellowing	2	0	0	0	–	–	–	–	1	0	0	0	–	–	–
8 Mottle	11	5	1	0	–	–	–	–	–	–	–	–	–	–	–
9 Crinkle	–	–	–	–	–	–	–	–	–	0	0	–			
6+2	3	4	0	0	–	–	–	–	–	–	–	–	1	0	0
6+5	2	1	0	0	–	–	–	–	–	–	–	–	–	–	–
6+3	32	27	0	0	5	4	0	0	2	0	0	0	2	0	0
6+4	4	3	0	0	–	–	–	–	–	–	–	–	–	–	–
7+2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8+2	3	0	0	0	–	–	–	–	–	–	–	–	–	–	–
8+6	–	–	–	–	–	–	–	–	3	0	0	0	–	–	–
8+6+3	–	–	–	–	–	–	–	–	4	0	0	0	–	–	–
Total	264	132	9	5	82	51	32	24	262	40	27	13	140	30	0

[z]T = total no. of leaves sampled; A = positive for SPV-A; N = positive for SPV-N.

Conclusion

The results of this study indicate that an ELISA test of one or a few individual leaves per plant may not be adequate to determine if a plant is infected with these viruses. To ascertain whether meristem-derived small plantlets are free of SPV-A and/or SPV-N, it may be necessary to excise all leaflets and pool these for testing by ELISA. Although ELISA is considered one of the more sensitive serological methods, additional testing of meristem-derived plants by grafting to susceptible indicator plants is recommended for future virus indexing of meristem-derived plantlets.

Virus Indexing of Meristem-Derived Sweet Potato Plantlets

Introduction

For the import of sweet potato germplasm, many countries require a phytosanitary certificate indicating absence of virus. One practical and efficient way of freeing vegetatively propagated plant materials from virus, is by meristem culture because it has been shown that viruses usually do not move into the apical cells as soon as these are formed. The ease with which meristems can be rid of virus depends on the particular host and the virus. Subsequent testing of meristem-derived plantlets for the absence of viruses is, however, paramount because it can not always be assured that the excised apex does not contain a few cells where the virus has already become established.

Materials and Methods

Meristems of 16 sweet potato breeding lines and five accessions were tested. Two leaflets of meristem-derived plantlets, and one leaf each of plants, rooted leaf cuttings, and of plants derived from roots of the leaf cuttings were tested by ELISA for the presence of SPV-A and SPV-N. For the detection of SPV-A, antiserum to the common strain of feathery mottle virus (FMV-C), provided by J. W. Moyer, North Carolina State University, Raleigh, USA, which was previously shown to react positively with SPV-A was used at a dilution of 1:500 for both

the coating gamma globulin and the enzyme conjugate. For the detection of SPV-N, dilutions of 1:1000 of both coating gamma globulin and enzyme conjugate were used.

Results

The results of the virus indexing of the individual breeding lines and accessions are shown in Table 2. Of the 2,151 leaf samples tested, 26 were found infected with SPV-A and 106 with SPV-N. The relatively high percentage of meristem-derived plantlets found infected with SPV-N (11.8%) compared to that of plants infected with SPV-A (3.8%) indicates that the first mentioned virus is probably not as easily eliminated through meristem culture as is SPV-A. However, for both viruses the actual percentage may be higher because it has been shown in another study that both SPV-A and SPV-N are not evenly distributed within the plant and, thus, may not be detected in every leaf in an infected plant.

The presence of virus in both plants(R) and rooted leaf cuttings(R) is most likely due to the fact that SPV-N may not be as easily eliminated through meristem culture as SPV-A (Table 2). It may also be caused by the fact that with the present method of virus detection, particularly that of SPV-N has remained unnoticed in some of the original meristem-derived plantlets. However, the presence of both viruses in plants and rooted leaf cuttings may also be caused by re-infection by natural vectors in the provisionary screenhouse where the plants were kept.

Conclusion

In the future to assure freedom of virus, it may become necessary to use all the leaves of the meristem-derived plantlets for the ELISA test instead of only two leaves, as was done so far. Additional tests at a later stage, such as grafting to susceptible indicator plants, may also have to be used. To further reduce the presence of virus in meristems, heat treatment of sweet potato vines or tubers prior to excising the meristems is recommended.

Table 2. Presence of SPV-A and SPV-N in meristem-derived plants.[z]

Sweet Potato Accession/Line	Plantlets from Meristems (M)			Plants from Node Cuttings of M (P)			Rooted Leaf Cuttings from P (C)			Mature Plants Derived from P (R)		
	T	A	N	T	A	N	T	A	N	T	A	N
AIS35-2	18	–	–	2	–	–	342	–	11	12	–	–
AIS0122-2	18	1	–	10	–	–	239	–	12	–	–	–
CN1038-16	50	–	3	19	–	2	170	1	–	–	–	–
CN1108-13	57	9	8	17		2	417	4	18	–	–	–
CN1229-16	29	3	3	1	–	1	–	–	–	–	–	–
CN1028-15	8	–	–	6	–	–	28	2	–	–	–	–
CN1058-10	27	2	5	17	1	6	12	1	–	–	–	–
CN1232-9	6	–	2	1	–	–	–	–	–	–	–	–
CN941-32	15	–	3	20		3	125	–	–	–	–	–
CN1219-1	24	–	2	10	–	–	113	1	1	–	–	–
CN1367-2	32	–	9	29	–	11	1	–	–	–	–	–
CN1419-172	22	–	–	–	–	–	–	–	–	–	–	–
CN1280-3	7	–	1	1	–	1	–	–	–	–	–	–
CN1121-312	11	–	–	–	–	–	–	–	–	–	–	–
CN1421-56	1	–	–	–	–	–	–	–	–	–	–	–
CN1424-153	1	–	–	–	–	–	–	–	–	–	–	–
I57	9	–	1	9	–	–	55	–	3	–	–	–
I423	4	–	–	4	–	–	20	–	–	–	–	–
I444	53	–	4	3	–	–	60	–	–	–	–	–
I66	2	–	–	–	–	–	–	–	–	–	–	–
I424	10	–	6	–	–	–	–	–	–	–	–	–
Total	404	15	47	149	1	26	1582	9	45	12		

[z]T = total plants; A = SPV-A; N = SPV-N; – = no virus present.

Sweet Potato Physiology

Production of Small Virus-Free Sweet Potato Storage Roots by Meristem-Tip Culture and Leaf-Cutting

Introduction

There are only a few improvement programs in the major sweet potato production regions of the world, i.e., Asia and the Pacific. This fact forces most countries to depend on imported source of improved germplasm. To avoid the dissemination of insects and diseases through the conventional propagation of vine cuttings or storage roots, several research institutes use tissue-cultured materials to transfer improved germplasm.

Improved materials transported in this form, however, may suffer from exposure to extreme temperatures and/or rough handling. Furthermore, even if the materials arrive intact, regeneration may be complicated by a lack of facilities or personnel capable of handling tissue-cultured materials. The purpose of this study is to develop a method that can produce a high percentage of healthy plants as rapidly as in the tissue-culture method presently being used for international germplasm exchange.

Materials and Methods

Apical shoots 2 to 3 cm long were excised from the sprouting storage roots. They were trimmed to a length of 1.2 to 1.5 cm before surface-sterilizing with 0.5% NaOCl for 10 min, and rinsed three times with sterile, distilled water. Meristem tips (0.2 to 0.4 mm) were dissected and aseptically explanted to culture tubes containing 6 ml of MS high mineral salt medium. Meristem-tip culture tubes were placed in a 15-hr photoperiod growth room with temperatures ranging from 22° to 32°C.

Once plantlets with two to three leaves were established usually after two months, the leaves were taken for virus-indexing by ELISA method. Virus-infected plantlets were discarded, but virus-free plantlets were grown for an additional two months. When the virus-free plantlets were ca. 70 mm tall, they were cut into four or more pieces, each piece containing a single node and explanted to fresh standard medium. Plantlets derived from them were transferred to 20 cm clay pots containing a sterilized mixture of soil and sand (1:1). The pots were maintained in an insect-free screenhouse with 60% prevailing sunlight intensity at 11:00 a.m. and temperatures ranging from 25° to 35°C.

Once established, the plants were staked with bamboo poles. Fully expanded leaves were cut at the base of the petiole and transplanted to 10 cm plastic pots containing a sterilized soil and sand mixture. The pots were then placed in an insect-free screenhouse, where they were sprayed with a water mist eight times per day for 7 to 10 days to enhance leaf-cutting establishment. The leaf-cuttings were usually grown for two to three months for storage root development. Before harvesting the small storage roots on rooted leaf-cuttings, parts of the leaf blades were cut and tested for virus. Storage roots from virus-free leaf cuttings were then washed to remove the soil, and dipped in Dithane M-45 before curing for three days at 32°C. Small storage roots were either stored at 15°C and/or distributed to cooperators upon requests.

Results

Within four months of culturing, the average percentage of plantlets established from meristem tips for all entries was about 41%, ranging from 8 to 87% (Table 1). Once plantlets were obtained from the meristem tips, they were easily multiplied by the culturing of single-node cuttings. Plantlets usually developed within one month from single-node cuttings.

Of the 423 established plantlets tested for SPV-A and SPV-N by ELISA, 355 (84%) were found to be virus-free. More than 80% of the virus-free plantlets survived when transplanted into the sterilized sand-soil mixture. After one or two months, these plants were ready for leaf-cuttings. Leaf-cuttings of all entries without side shoot development were able to form storage roots within 60 to 100 days. The average percentage of leaf-cuttings which produced small storage root was about 55%(ranging 24 to 81%)(Table 2). The storage roots were similar in exterior and interior color to those of the parental clone. Of the 1,521 leaf-

Table 1. Numbers of cultured meristem tips, surviving plantlets, and virus-free plantlets of sweet potato grown for 60 days in MS medium with kinetin and IAA at 1 mg/l.

Entries	No. of Meristem Tips Cultured	No. (%) of Surviving Plantlets	No. (%) of Virus-Free Plantlets
I 57	60	6 (10)	5 (83)
I 367	45	13 (29)	6 (46)
I 423	50	4 (8)	4 (100)
I 981	30	5 (17)	5 (100)
I 424	24	18 (75)	12 (67)
I 444	50	16 (32)	15 (94)
AIS35-2	40	19 (48)	19 (100)
AIS0122-2	40	19 (48)	18 (95)
CN941-32	50	15 (30)	12 (80)
CN1028-15	50	10 (20)	10 (100)
CN1038-16	80	51 (64)	48 (94)
CN1058-10	50	24 (48)	18 (75)
CN1108-13	80	60 (75)	45 (75)
CN1121-312	21	12 (57)	12 (100)
CN1219-1	30	26 (87)	21 (81)
CN1229-16	60	27 (45)	21 (78)
CN1232-9	30	9 (30)	7 (78)
CN1280-3	50	15 (30)	12 (80)
CN1367-2	200	36 (18)	27 (75)
CN1419-172	73	38 (52)	38 (100)

Table 2. Storage-root formation and the rate of virus re-infection of virus-free leaf-cutting[z].

Entries	No. of Leaf-Cuttings Cultured	No. of Leaf-Cuttings with Storage Roots (%)	Virus Re-infection on Leaf-Cuttings (%)
I 423	36	20 (56)	0
I 57	135	42 (31)	7.0
I 444	77	48 (62)	0
AIS35-2	419	340 (81)	1.8
AIS0122-2	363	235 (65)	4.3
CN941-32	278	124 (45)	0
CN1028-15	62	42 (68)	4.7
CN1038-16	304	170 (56)	0.6
CN1108-13	630	375 (60)	5.0
CN1219-1	192	113 (59)	0.9
CN1058-10	51	12 (24)	8.0

[z]Leaf-cuttings were grown for 60 to 100 days under screenhouse conditions.

cuttings from 11 entries that were tested for SPV-A and SPV-N, less than 3% of leaf-cuttings were found to be infected. Re-infection of virus on leaf-cuttings could be attributed to the use of a rather primitive screenhouse for culturing plants and leaf-cuttings. However, the possibility of not detecting the virus in original plantlets will be further examined.

When the small, virus-free storage roots were replanted, the plants that developed were similar to the parental clone. There was no distinct difference in the sprouting ability of the small storage roots harvested one to three months after the initial culture of the leaf-cuttings.

Conclusion

Once virus-free plantlets were obtained through meristem-tip culture, virus-free storage roots could be produced on leaf-cuttings acquired from grown plants in just a short time. Virus-free plantlets could be multiplied at a rate of four per month by the *in vitro* single-node method. This means that a meristem tip produced a plantlet from which an average of four plantlets could be obtained each month for developing into mature plants as source of leaf-cuttings. Mature plants produced an average of 15 leaves per plant per month. The average percentage of leaf-cutting which produced small storage roots was about 50% in two months; hence, an average of 22 virus-free storage roots could be produced from a single established plant after six months. After completion of leaf-cutting, mature plants can be maintained and regenerated through the formed storage roots or vine cuttings, thus shortening the regeneration cycle.

The genetic fidelity of the resulting plants from the storage roots through meristem-tip culture and leaf-cutting appeared to be assured. Therefore, this system may represent a better means of disseminating virus- free sweet potato materials, principally because storage roots are easier to ship, handle, and store than plantlets in test tubes (Fig. 1, see next page).

Influence of Leaf Age and Petiole Length on Storage Root Formation of Sweet Potato Leaf-Cuttings

Introduction

The leaf-cutting method for producing storage roots is a convenient technique for multiplying virus-free sweet potato materials. However, there are variations in the ability to produce storage roots from leaf-cuttings of the same plant. The present study examines the influence of leaf age and petiole length on storage-root formation of sweet potato leaf-cuttings.

Materials and Methods

Plants of AIS 35-2 were grown and staked in the field from July 30 to September 18, 1984. Fully expanded leaves were labelled and recognized as age 1 day. Leaves at ages 1, 4, 8, 11, 15, 18, and 22 days were cut at the basal part of the petiole on the same day. They were immediately transplanted to clean, black plastic pots (ID 9 cm) containing a mixture of soil, sand, compost (3:1:1) as the growing medium. Leaf-cuttings were grown in the greenhouse at low light intensity but high humidity. Survival rates of leaf-cuttings were taken weekly, and storage-root formations on leaf- cuttings were investigated at 69 days after planting.

In another study to examine the possibility of avoiding side-shoot formation on leaf-cuttings, which usually prevents storage-root formation, leaf-cuttings (aged three days) were cut with full petiole length, without petiole base, two-thirds of petiole length, or one-third of petiole length. These leaf-cuttings were grown and observed as previously described.

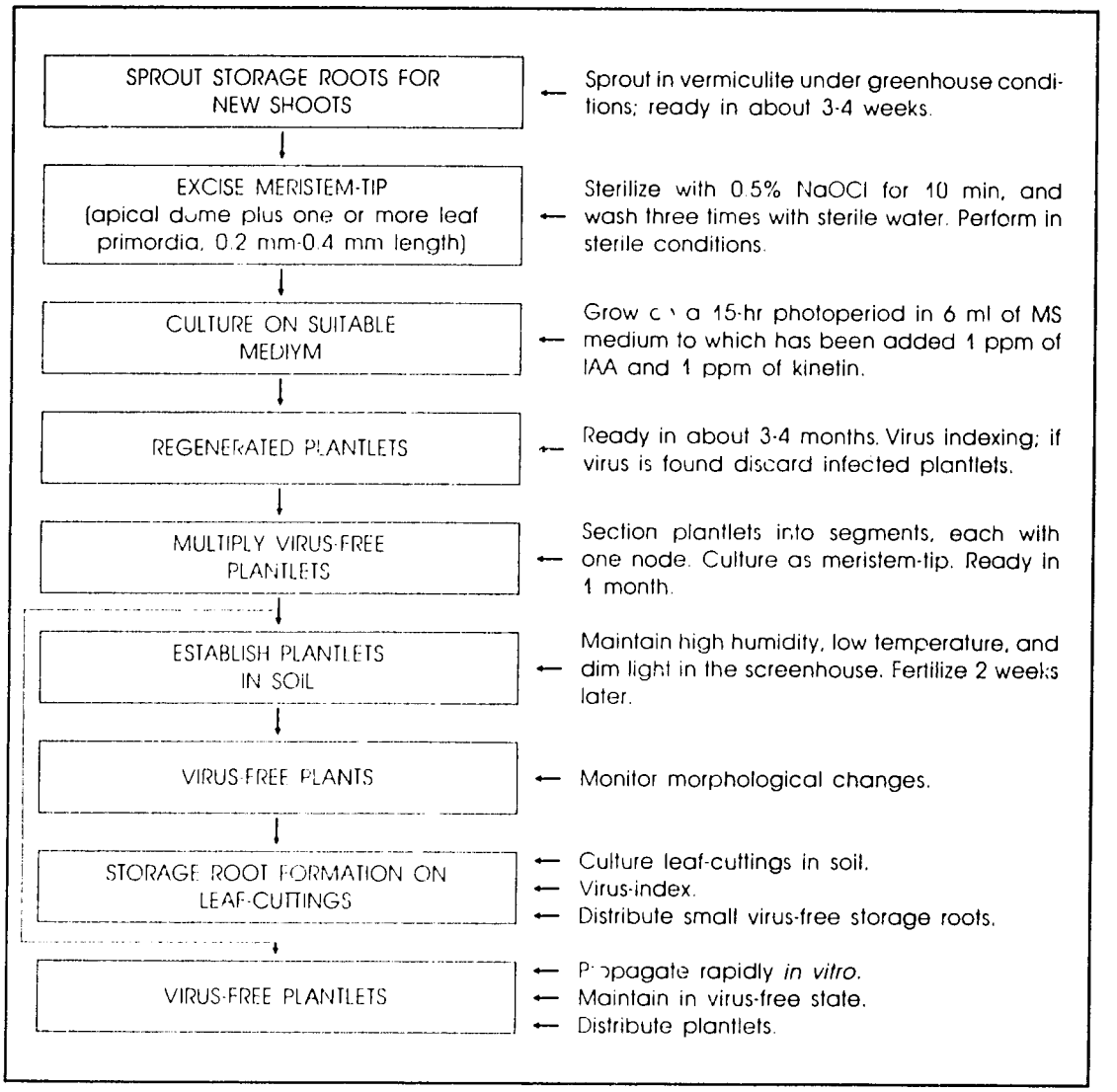


Fig. 1. Scheme for the production of small virus-free storage roots through meristem-tip culture and leaf-cutting.

Results

None of the leaf-cuttings aged 11, 14, 18, and 22 days survived beyond 21 days after planting in the plastic pots. These leaves usually gradually turned yellow and brown before dying off. Storage roots were formed on leaf-cuttings aged 1, 4, and 8 days (Table 3). There was no significant difference in size and number of storage roots formed on leaf-cuttings. However, younger leaf-cuttings tended to have high rates of storage-root formation. The influence of leaf age before full expansion was not examined in this experiment.

There was also no significant difference in size and number of storage roots formed from leaf-cuttings with different petiole lengths (Table 4). None of these leaf-cuttings formed any side shoots, which may be due to the removal of the petiole base. However, leaf-cuttings with short petiole lengths had more storage roots. This deserves further investigation.

Table 3. The influence of leaf age on growth of sweet potato leaf-cuttings.

Leaf Age (days)	Fresh Wt (g/cutting)				No. of Storage-Root Cutting	Storage-Root Formation (%)
	leaf	petiole	fibrous root	storage root		
1	2.2±0.6	1.0±0.3	3.9±1.1	2.0±1.4	1.1±0.5	94
4	2.5±0.3	1.4±0.2	3.7±0.8	3.3±1.3	1.0±0	100
8	1.0±1.1	2.1±0.5	5.2±0.8	1.2±1.3	0.9±0.7	71

Table 4. The influence of petiole length on growth of sweet potato leaf cuttings (aged 3 days).

Petiole Length	Fresh Wt (g/cutting)				No. of Storage-Root Cutting	Storage-Root Formation[z] (%)
	leaf	petiole	fibrous root	storage root		
Full	1.7±0.7	1.1±0.3	3.0±1.2	1.4±1.8	0.6±0.8	44b
Two-thirds	1.7±0.7	0.9±0.3	3.1±0.9	1.3±1.3	0.7±0.6	66ab
One-third	1.8±0.8	0.4±0.1	3.8±0.4	2.0±1.2	0.9±0.4	88a

[z]Mean separation within column by Duncan's Multiple Range Test, 5% level.

Conclusion

Sweet potato leaf-cuttings initiate fibrous roots readily, some of which develop storage roots. Newly expanded leaves had better chances of survival, thereby increasing the chance of storage-root formation. The retention of one-third of petiole length prevented side-shoot growth and did not affect storage-root formation.

Responses of Sweet Potato Leaf-Cuttings to Drought

Introduction

Sweet potato is usually grown in marginal land area where plants are often subjected to drought stress. It is important that the AVRDC sweet potatoes possess differences in storage-root formation under drought stress conditions, and to examine the feasibility of using PVF strips as water carrier to maintain low soil-water status for the purpose of screening for drought tolerance.

Materials and Methods

Ten entries of AVRDC-improved breeding lines and accessions were examined (Table 1). Leaf-cuttings were prepared from their newly expanded leaves, and grown in black plastic pots as previously described. Leaf- cuttings with their growing medium were later transferred to PE tubes (ID = 9 cm, height = 20 cm) filled with a mixture of soil, sand, and compost (3:1:1).

PVF strips 2.5 in width were inserted into the bottom of PE tubes before transplanting the leaf-cuttings. PVF strips of 10 cm in length were buried in the growing medium with PVF lengths at 30, 40, 50, or 60 cm extending from the bottom of the PE tubes to the water surface. This was done to create a different water status in each of the growing medium in the PE tubes.

PVF strips outside the PE tubes were wrapped in black PE film to prevent algal growth on these strips and water evaporation. There were nine leaf-cuttings for each entry, in each PVF length. At the final harvest, leaf-cuttings were investigated for fresh and dry weights of blade, petiole, fibrous root, and storage root.

For the first experiment, leaf-cuttings were grown in plastic pots for 44 days and then in PE tubes for 35 days with different PVF lengths. In the second experiment, leaf cuttings were grown in plastic pots for 23 days and then in PE tubes with PVF strips for 73 days.

Results

PVF length did not influence storage-root production of leaf-cuttings in most entries, except in CN1028-15 and CN1121-312 (Table 5). This was most likely due to the penetration of fibrous roots along the PVF strips to reach the water in the reservoir, rather than an indication of genotypic tolerance to drought stress. Although long PVF strips created drought stress in PE tubes, the ability of fibrous roots' to penetrate PVF strips makes the evaluation of drought tolerance on this method difficult.

Similarly, there was no clear reduction of storage-root production with the increase of PVF length in the second experiment, except in CN1108-13 and TN65 (Table 6). In the second experiment, tissue paper was used to wrap around the PVF portion buried in the soil to prevent root penetration along the PVF strips, but the attempt failed regardless of PVF length.

However, our results still clearly demonstrated the practicality of using leaf-cutting for screening and other research purposes. AVRDC's improved high-yielding breeding line, CN1028-15, had the highest storage-root yield on leaf-cuttings among 10 entries in the present study (Tables 5 and 6). The results confirmed the high-yielding potential of CN1028-15 in the field.

Table 5. Storage root fresh weight (g/cutting) of various sweet potatoes grown with water supplied through different PVF lengths for 35 days[z].

Entry	PVF Length (cm)			
	40	50	60	70
AIS35-2	4.03bc	3.78c-e	2.03d-f	3.45ab
CN942-47	7.05b	5.82b-d	3.96c-e	5.22ab
CN1028-15	a16.11a	ab13.62a	bc9.94a	c8.38a
CN1038-16	0.26c	1.10e	0.16f	0.47b
CN1108-13	0.64c	2.06de	5.02b-d	3.98ab
CN1121-312	ab6.94b	a8.18b	a7.83ab	b2.97ab
CN1280-4	0.64c	0.43e	0.71ef	0.27b
Kinmen	6.72b	7.14bc	5.48bc	5.59ab
TN57	2.63bc	2.65de	2.01d-f	3.87ab
TN65	2.77bc	1.68e	1.89d-f	3.12ab

[z]Letters to the right: mean separation within columns by Duncan's Multiple Range Test, 5% level; to the left: mean separation within rows by DMRT, 5% level.

Table 6. Storage root fresh weight (g/cutting) of various sweet potatoes grown with water supplied through different PVF lengths for 23 days[z].

Entry	PVF Length (cm)			
	40	50	60	70
AIS35-2	2.45e	1.71d	7.49c	2.93d
CN942-47	5.34de	7.04bc	7.79a-c	7.86a-c
CN1028-15	14.55ab	15.75a	14.86a	12.52a
CN1038-16	1.69e	1.19d	5.80bc	0.44d
CN1108-13	a13.97a-c	ab7.59bc	b2.19c	ab9.30ab
CN1121-312	8.94cd	8.38b	7.79a-c	5.26b-d
CN1280-4	2.73e	2.51d	1.58c	0.9d
Kinmen	17.06a	18.61a	13.55a	12.03a
TN57	4.01de	4.15cd	5.08bc	3.38cd
TN65	a11.54bc	a8.84b	a9.81ab	b4.17cd

[z]Letters to the right: mean separation within columns by Duncan's Multiple Range Test, 5% level; to the left: mean separation within rows by DMRT, 5% level.

Conclusion

PVF strips are potentially useful for sweet potato drought-stress study and screening. However, the technique needs further improvement. Of all entries grown from bleaf-cuttings supplied with water through PVF strips, the AVRDC high-yielding CN1028-15 was the highest storage-root yielder. The leaf-cutting technique could be an easier method for research and screening purposes.

164

Legume Crops Program

Mungbean Breeding

Germplasm Collection

A total of 119 mungbean accessions were received from Pakistan. Through an IBPGR project in cooperation with Japanese, Thai, and Laotian scientists, Dr. Talekar collected 24 mungbeans from Laos. Also obtained were *Vigna mungo* (65), *V. unguiculata* (42), *V. umbellata* (5), other *V.* species (29), and *Phaseolus vulgaris* (3) from Pakistan and Laos (Table 1). The total mungbean collection at the end of 1984 was 5,263

Table 1. Germplasm received in 1984.[z]

Country	*V. radiata*	*V. mungo*	*V. unquiculata*	*V. umbellata*	*P. vulgaris*	*V. sp.*
Pakistan	119	65	18	–	–	–
Laos	24	–	24	5	3	29
Total	143	65	42	5	3	29

[z]Mungbean collection in 1983: 5,120; 1984: 143; total: 5,263.

Germplasm Evaluation

Introduction

New accessions are screened to determine the characters of value that may be useful for our breeding program. Outstanding accessions can even be directly included in the International Mungbean Nursery (IMN). Evaluation of germplasm by the national program may uncover traits valuable for their specific breeding program so that rapid progress can be made by them

Materials and Methods

One hundred and twenty-eight accessions from Pakistan were planted on March 6, 1984. Each entry was planted in 3-m-long rows with a spacing of 50 cm between rows and 10 cm between hills. Two plants were left per hill

From the March planting, 24 accessions were selected and planted on July 27, 1984. Each entry was planted on two 3-m-long rows with a spacing of 50 cm between rows and 8 cm between single-plant hills within the row. AVRDC's suggested cultural practices were followed

At the National Agricultural Research Center in Islamabad, Pakistan, 966 AVRDC accessions were planted on July 15, 1984. Each entry was planted on a single 3-m-long row with a spacing of 30 cm between rows and 10 cm between plants. No irrigation was provided. However, 623 mm rainfall was recorded during the crop growth period

On all the three trials, observations were made on days to flowering, maturity, percentage of the total yield in the first harvest, 1000-seed weight, powdery mildew (PM) and *Cercospora*

leaf spot (CLS) disease rating, lodging, and yield per plot. In Pakistan, accessions were rated for CLS, bacterial leaf spot (BLS), leaf crinkle virus (LCV), mungbean yellow mosaic virus (MYMV), and anthracnose

Results

Among the 128 accessions from Pakistan, nine were *V. mungo* and 119 were *V. radiata*. The mean and range of 119 mungbean accessions for various measurements are given in Table 2. Among the characters examined, considerable variations were observed in the following: percentage of total yield at first harvest, 1000-seed weight, lodging, and yield. Seed coat of 64 accessions were shiny, while the remaining 45 were dull. Moderate resistance to PM was observed on 61 accessions. The characteristics of selected entries with more than 80% of the total yield at first harvest and some level of resistance to PM are given in Table 3

In the March planting entries 40528 and 40549 had the heaviest 1000-seed weight (Table 3). Both entries had large seeds in the July planting as well. Entry 40576 had the lowest CLS and PM rating but the yield was very low. Entries with high yield and resistance to one or more disease are shown in Table 4

In Pakistan the mean of days to flowering of 940 (out of 966) accessions which flowered was 55 ± 4.9 and the range was 40 to 68. Among them 740 matured. The range in maturity was 62 to 87 with a mean of 80 ± 2.8.

Yield data collected for 724 accessions varied from 8 kg to 958 kg/ha with a mean of 160 ± 132 kg/ha. The coefficient of variation for yield was 82.2% and, therefore, the yield data should be viewed with caution

Among the five diseases for which ratings were made, there was low resistance to bacterial leaf spot and anthracnose (Table 5). Since the mungbean yellow mosaic virus (MYMV) was not severe, the germplasm has to be rescreened for MYMV. In order to verify the level of resistance to different diseases, accessions from disease reaction rating 1 has to be preferably rescreened.

Table 2. Mean and range of Pakistan accessions in the March 1984 planting.

Observation	Mean	Range
Days to flowering	46 ± 1.2	44-50
Days to maturity	66 ± 1.5	63-69
Total yield percentage at first harvest	56 ± 23.2	5-98
1000-seed weight (g)	31 ± 7.1	23-64
Lodging[z]	3.6 ± 1.1	1-5
Yield (kg/ha)	460 ± 179	167-960

[z] 1 = no plant lodging, 5 = all lodging

Table 3. Performance of selected accessions in the March 1984 planting.

Pakistan Entry No.	Total Yield at First Harvest (%)	Powdery Mildew[z]	1000-Seed Wt (g)
40450	98	3	27
40516	97	2	28
40444	96	3	27
40549	91	4	61
40528	90	5	58
40467	87	2	27
40471	86	2	27
40454	85	2	28
40451	84	2	28
40480	84	2	28
40525	80	2	24

[z] 1 = highly resistant, 5 = highly susceptible.

Table 4. Selected accessions and their performance in the July 1984 planting.

Pakistan Entry No.	Yield (kg/ha)	*Cercospora* Leaf Spot[z]	Powdery Mildew[z]	1000-Seed Wt (g)
40527	1.114	2	4	34
40553	1,011	2	3	34
40558	642	3	2	33
40576	334	2	2	30
40577	954	2	3	33
40589	1,073	2	4	34
40702	1,065	3	5	32

[z]1 = highly resistant, 5 = highly susceptible.

Table 5. Disease reaction of mungbean germplasm evaluated in Pakistan.[z]

Reaction Scale 1-5[y]	No. of Entries for[x]				
	CLS	BLS	LCV	MYMV	Anthracnose
1	60	3	95	225	21
2	294	141	743	712	190
3	384	794	105	6	362
4	202	5	–	–	192
5	3	–	–	–	178

[z]Total: 943 accessions. [y]Rating: 1 = highly resistant, 2 = resistant, 3 = intermediate, 4 = susceptible, and 5 = highly susceptible. [x]CLS = *Cercospora* leaf spot; BLS = bacterial leaf spot, LCV = leaf crinkle virus; MYMV = mungbean yellow mosaic virus.

Conclusion

An exchange of mungbean germplasm between Pakistan and AVRDC was mutually beneficial in identifying valuable genetic resources to strengthen the ongoing breeding program. Accessions with synchronous maturity and disease resistance have been identified. Selected accessions should be evaluated in a replicated yield trial, and the disease resistance need to be confirmed.

Crossing Program

Introduction

To develop new genotypes, hybridization is commonly used. Hybridi-zation is also used to understand the inheritance of desired characte-ristics. With the objective of enhancing resistance to CLS and PM and improving the synchronized maturity of the AVRDC selections, 212 crosses were made.

Materials and Methods

The 26th crossing block planted in March 1984 had 19 breeding lines and five accessions, while the 27th crossing block planted in July consisted of 15 breeding lines and seven accessions. As in the past, the emphasis was to combine high yield potential, synchronized maturity, and resistance to diseases. Specific crosses were made to study the inheritance of resistance to *Cercospora* leaf spot (CLS) and powdery mildew (PM). Crossed with selected mungbean and black gram either to combine bruchid resistance or to improve the methionine content of mungbean are the following nine *V. radiata* var. *sublobata:* TC1965, TC1966, TC2185, TC2186, TC2207, TC2208, TC2209, TC2210, and TC2211.

Results

The number of crosses made is shown in Table 6.

VC1560D and V2773 (both resistant to CLS and PM) were crossed with V2010 (very susceptible to CLS) and V1944 (very susceptible to both CLS and PM), and 14 crosses and back crosses were used to study the inheritance of resistance to CLS and PM.

Four lines identified as resistant to bruchid by the entomologist in the BC_1F_2 generation of the cross between MG143, a bridge, and VM2164 were crossed with mungbean to improve the agronomic characters of the selections.

Three bridge lines brought by Dr. Ahn from Hawaii (IC_1, IC_2, and IC_3) and three mungbean × black gram received from India (MG_1, MG_2 and MG_3) were used as bridging species in wide crosses between black gram (VM2135, resistant to pod borer; VM2164, resistant to bruchid; and UG191, with high methionine content) and mungbean. The bridging species, black gram and *V. radiata* var. *sublobata*, were all being evaluated for methionine content by the chemist.

Conclusion

Screening populations derived from new combinations will help in the identification of resistance to insects and diseases which can be recombined with other desirable characters.

Table 6. Number of mungbean crosses made in 1984, AVRDC.

Objective	Number of Crosses Made
To combine high yield, disease and/or insect resistance, synchronized maturity, and photoperiod insensitivity	212
To study the genetics of CLS and PM resistance	14
Wide cross between bridge species and black gram and the resulting selection to be crossed with mungbean	1
Total	227

Preliminary, Intermediate, and Advanced Yield Trials

Introduction

Outstanding selections from bulk, pedigree, or back cross methods have to undergo different levels of yield evaluation in different seasons, so that their credibility and yield potential can be established. In addition to yield, the selections are also evaluated for resistance to diseases and photoperiod sensitivity.

Materials and Methods

The following yield trials were conducted in 1984: preliminary (PYT), intermediate (IYT), advanced (AYT), elite (EYT), and Interna-tional Mungbean Nursery (IMN). The details of the trials are given in Table 7.

Results

Preliminary yield trial-I (PYT-I). Among 81 entries evaluated, 67 in February, 16 in July, and 29 in February and July significantly outyielded the check cultivar V3476 in a pooled analysis. The range of yield in the high-yielding entries varied among themselves and in comparison with the checks (Tables 8 and 9).

Table 7. Different mungbean yield trials conducted in 1984, AVRDC.

Type of Trial[z]	No. of Entries (check)[y]	Sowing Date	Harvesting Date 1st	2nd	3rd	Plot Size (m^2)	Experimental Design	No. of Reps.
Spring Planting[w]								
IMN	20	3/2	5/24	6/7	6/21	18	RCBD[x]	3
EYT	22 (2)	3/13	5/25	6/7	6/21	18	RCBD	5
AYT	30 (2)	2/29	5/18	5/30	6/19	12	RCBD	4
IYT	64 (1)	2/29	5/22	6/5	6/18	6	Lattice (8×8)	3
PYT-I	81 (1)	2/29	5/19	6/6	6/20	6	Lattice (9×9)	3
PYT-II	100 (1)	2/29	5/17	6/5	6/18	6	Lattice (10×10)	2
Summer Planting[v]								
IMN	20	7/18	9/26	10/19		18	RCBD	3
EYT	22 (2)	7/18	9/24	10/16		18	RCBD	5
AYT	30 (2)	7/26	10/4	11/6		12	RCBD	4
IYT	64 (1)	7/27	10/9	11/8		6	Lattice (8×8)	3
PYT-I	81 (1)	7/27	10/8	11/7		6	Lattice (9×9)	3
PYT-II	100 (1)	7/18	9/25	10/22		6	Lattice (10×10)	2
PYT-III	114 (1)	7/27	10/5	11/6		5	RCBD	2
Fall Planting[w]								
IMN	20	9/18	12/4	12/19		16.5	RCBD	3
EYT	22 (2)	9/20	12/3	12/20		16.5	RCBD	5
AYT	30 (2)	9/18	12/4	12/19		11	RCBD	4
IYT	64 (1)	9/21	11/30	12/20		6	Lattice (8×8)	3
PYT-I	81 (1)	9/20	12/3	12/19		6	Lattice (9×9)	3
PYT-II	100 (1)	9/21	12/3	12/20		6	Lattice (10×10)	2

[z]IMN = International Mungbean Nursery; EYT = elite yield trial; AYT = advanced yield trial; IYT = intermediate yield trial; PYT = preliminary yield trial. [y]V3476 and V3726 in EYT, V3476 and V6094 in AYT, V3476 in IYT, PYT-I and PYT-II, and VC2768A in PYT-III. [x]Randomized complete block design. [w]Plant population density was 400,000 plants/ha. [v]Plant population density was 250,000 plants/ha.

Table 8. Range in values for various parameters of entries performing significantly better than the check V3476 in preliminary yield trial-I, 1984, AVRDC.

Planting Date	Yield (t/ha)	First Harvest (%)	Number of Entries with Moderate Resistance *Cercospora* leaf spot	Powdery mildew
February	(67)[z] 2.1-2.8	(51) 62-66	–	45
July	(18) 1.7-2.0	(37) 87-94	62	40
Feb. & July pooled	(29) 2.0-2.3	(2) 78-80	62	40

[z]Number of entries significantly outyielding the check V3476 are in parenthesis.

Table 9. Entries with a high level of resistance to both CLS and PM in preliminary yield trial-I, 1984, AVRDC.

AVRDC Cross No.	Parentage	Yield (t/ha) Feb.	July
VC3528-2B-3-B-2	VC1560D/VC2533A	2.4	1.7
VC3658-B-3-B-3	VC1168B/VC2528B	2.5	1.6
VC3696-B-3-B-2	VC2530C/VC2778A	2.2	1.3
VC3689-1-1-B-1[z]	VC2527A/VC4718	2.2	1.3
VC3732-B-3-B-2	V5000/VC2530C	2.1	1.2
V3476 (Ck)[y]	CES1D-21	1.9	1.4
CV (%)		7	11
LSD (.05)		0.25	0.28

[z]Observed to be one of the best for CLS resistance in July planting. [y]Moderately susceptible to CLS and very susceptible to PM.

The number of entries with significantly higher percentage of total yield in the first harvest is also shown in Table 8.

Nearly 77% of the entries screened had moderate to high levels of resistance to *Cercospora* leaf spot (CLS), while only 49% of the entries had such resistance to powdery mildew (PM). Five entries with a combined high level of resistance to CLS and PM should be useful in future crossing programs (Table 9). VC3689-1-1-B-1 had almost no CLS in the July planting.

The 10 highest yielders in the February and July pooled data are shown in Table 10.

Preliminary yield trial-II (PYT-II). In the February planting three selections gave a yield of more than 3 t/ha (Table 11). Out of 100 entries evaluated, seven entries significantly outyielded check V3476 in the February and 51 entries in the July planting. In the combined February and July analysis, 30 entries had significantly higher yield. Nine top entries are presented in Table 11. The highest total yield in the first harvest was 62% in the February and 75% in the July plantings.

Table 10. Performance of high-yielding entries in the preliminary yield trial-I conducted in the February and July 1984 plantings, AVRDC.

AVRDC Cross No.	Yield (t/ha)			1st Harvest (%)		1000-Seed Wt (g)	Disease Rating[z]	
	Feb.	July	mean	Feb.	July		CLS	PM
VC3510-2B-6-B-1	2.6	2.0	2.3	60	83	58	MR	MS
VC3685-B-3-B-4	2.8	1.7	2.2	43	88	55	MR	MR
VC3664-B-2-B-1	2.8[y]	1.7	2.2	57	85	59	MR	MS
VC3678-B-1-B-1[x]	2.6	1.8	2.2	64	84	51	MR	MS
VC3695-B-9-B-1[x]	2.6	1.7	2.2	58	81	57	MR	MS
VC3513-2B-3-B-1	2.5	1.8	2.1	62	87	55	MR	MR
VC3526-2B-5-B-1[x]	2.4	1.8	2.1	56	74	54	MR	MR
VC3687-B-1-B-1[x]	2.6	1.7	2.1	60	89	58	MR	MR
VC3523-2B-7-B-1	2.6	1.6	2.1	61	87	49	MR	MR
VC3673-B-3-B-1	2.5[y]	1.7	2.1	47	79	50	MR	HS
V3476 (Ck)	1.9	1.4	1.6	51	83	58	MS	HS
Mean of 64 entries	2.3	1.5	1.9	55	86	56		
CV (%)	7	12	11	12	3			
LSD (.05)	0.25	0.28	0.34	10.46	3.58			

[z]CLS = *Cercospora* leaf spot; PM = powdery mildew; MR = moderately resistant; MS = moderately susceptible; HS = highly susceptible. [y]Shiny seed coat. [x]Insensitive to photoperiod.

Table 11. High-yielding lines from the prelirninary yield trial-II in February and July 1984 plantings, AVRDC.

AVRDC No.	Yield (t/ha)			1st Harvest (%)		Disease Rating[z]	
	Feb.	July	mean	Feb.	July	CLS	PM
VC3743-2B-1-1-B[y]	3.1	2.4	2.7	57	67	HR	MR
VC3737-1-2-1-2-B[y]	2.8	2.5	2.6	55	68	MR	HR
VC3738-2-1-1-1-B	2.8	2.4	2.6	56	65	HR	MR
VC3738-2B-2-1-B[y]	3.1	2.1	2.6	62	63	MR	MR
VC3741-2-1-1-1-B	2.9	2.1	2.5	58	68	HR	HR
VC3766-3B-2-B	2.9	2.1	2.5	62	60	MR	HR
VC3742-2B-2-1-B[y]	2.7	2.1	2.4	50	75	MR	HR
VC3737-2B-2-1-B	3.1	1.8	2.4	47	67	MR	HR
VC3758-1-1-1-1-B	2.6	2.3	2.4	46	70	HR	HR
V3476 (Ck)	2.4	1.2	1.8	50	69	MS	MS
Mean of 100 entries	2.5	1.7	2.1	49	67		
CV (%)	8	14	10	15	7		
LSD (.05)	0.37	0.48	0.40	0.02	0.01		

[z]CLS = *Cercospora* leaf spot; PM = powdery mildew; HR = highly resistant; MR = moderately resistant; MS = moderately susceptible. [y]Insensitive to photoperiod.

Among the entries presented in Table 11, VC3738-2-1-1-1-B, VC3741-2-1-1-1-B, and VC3758-1-1-1-1-B had the lowest CLS and PM scores. Except the check, all the other entries had a dull seed coat and were nonlodging.

Intermediate yield trial (IYT). In February, eight entries gave yields ranging from 3 to 3.3 t/ha which were significantly higher than the yield of the check V3476. However, all of them had a similar total yield percentage to V3476 in the first harvest. In the July planting, out of 64 entries evaluated 35 entries had yields ranging from 1.6 to 2.1 t/ha which were significantly different from the check's (V3476), yield of 1.3 t/ha. For the check, 86% of the total yield was obtained from the first harvest. In 12 breeding lines, 91 to 95% of the total yield were from the first harvest. Of them VC3604-2-1-1-1-B and VC3536-B-1-1-2-B had significantly higher yields than the check. The 12 selections should serve as excellent base materials for future hybridization program (Table 12).

A combined analysis of the February and July data showed that 15 entries outyielded check V3476. Data for six top entries are given in Table 13. Among them four entries had a good level of CLS resistance.

Among the 64 entries evaluated, 33 had acceptable levels of CLS resistance, while only 17 had a good level of PM resistance. Four entries shown in Table 14 had a combined moderate resistance to both CLS and PM and should be valuable source materials for future crossing

Table 12. Selections from the intermediate yield trial with synchronized maturity useful for future crossing program.

AVRDC Cross No. or Acc. No.	Name or Parentage	Yield (t/ha)	First Harvest (%)
VC3604-2-1-1-1-B	S-8/VC1482C	1.6	92
VC3536-B-1-1-2-B	VC1973A/VC2530C	1.6	95
VC3525-B-1-3-1-B	VC1482C/VC2770A	1.6	91
VC3180-5-1-1-1-B	CES1D-21/VC1482C	1.5	95
VC3312-2B-2-1-2B	VC1482C/VC2564A	1.5	93
VC3029-3-1-1-2B	VC1482C/VC1560D	1.4	95
VC3339-B-1-1-1-2B	VC1647B/VC1974A	1.4	91
VC3537-1-2-2-1-B	VC1973A/VC2533A	1.4	94
VC1560D-7-2B-1-B	BPI glab. 3/VC1301	1.4	92
VC3181-3B-3-B	CES1D-21/VC1535A	1.3	93
VC3552-2-1-3-1-B	VC2565A/VC2723A	1.2	94
VC3497-2B-3-1-2B	ML-65/VC1177B	1.1	93
V3476 (Ck)	CES1D-21	1.3	86
CV (%)		10	4
LSD (.05)		0.25	4

Table 13. High-yielding entries selected from the intermediate yield trial, 1984, AVRDC.

AVRDC Cross No.	Yield (t/ha)			First Harvest (%)		Disease Rating[z]	
	Feb.	July	mean	Feb.	July	CLS	PM
VC3178-3B-2-B	3.2	1.9	2.6	51	82	HR	MS
VC3300-2B-2-1-2B	3.2	1.9	2.6	49	83	MS	HS
VC3116-28-2B-2-B	3.3	1.7	2.5	51	83	MS	HS
VC3580-1-2-1-2-B	3.1	1.8	2.5	51	82	MR	HR
VC3004-3B-1-B	2.8	2.1	2.4	53	80	MR	MS
VC3029-5-2B-2-B	2.9	2.0	2.4	54	80	HR	MS
V3476 (Ck)	2.6	1.3	2.0	55	86	HS	HS
Mean of 64 entries	2.8	1.6	2.1	51	86		
CV (%)	8	10	10	17	3		
LSD (.05)	0.36	0.25	0.35	14	4		

[z]CLS = *Cercospora* leaf spot, PM = powdery mildew; HR = highly resistant; MR = moderately resistant; HS = highly susceptible, MS = moderately susceptible

programs. Since there appears to be different sources of resistance, the possibility of recombining these resistances to improve their levels should be explored.

Advanced yield trial (AYT). Mean yields of 30 entries evaluated in the February and July plantings were 2.3 and 1.5 t/ha respectively (Table 15). In a pooled analysis of the data from both seasons, three entries significantly outyielded the check V3476. The highest yielder in both plantings was VC3117-7-2B-2-B. Although VC2770-B-15-1-B had a similar yield to the check, the percentage of total yield at the first harvest was 94 in the July season. Most of the entries selected had a moderate to high level of resistance to CLS and PM. The mean 1000-seed weight of 30 entries was 57 g. All the three highest yielding selections had large seed size (47 to 58 g).

Elite yield trial (EYT). Among the 22 entries evaluated, two in the March planting and eight in July had significantly higher yield than the check. However, none of them had better synchronized maturity than the check. Many of the higher yielders had a resistance to either CLS or PM or both. Both large and small seed sizes (1000-seed weights of 66 and 43 g, respectively) were present among high-yielding entries (Table 16). A combined analysis of the March and July plantings revealed that VC2768A was the only entry significantly outyielding the check.

International mungbean nursery (IMN). In a combined analysis of the IMN March and July data, four cultivars had higher yield than the check V3476 (Table 17). Among the five released cultivars included in the IMN, V2984 (KJ5) had a yield of 1.5 t/ha, but it was not significantly different from any of the other four cultivars. Three of our breeding lines significantly outyielded V2984. Six entries were higher yielding than the check (V3476) in the March planting, but no entry was significantly higher yielding than the check.

Table 14. Entries with a high level of resistance to both CLS and PM.

AVRDC Cross No.	Parentage	Yield (t/ha)		Disease Rating[z]	
		Feb.	July	CLS	PM
VC3519-1-3-1-1-B	VC1209C/VC2635	2.9	1.7	MR	HR
VC3552-2-1-3-1-B	VC2565A/VC2723A	3.0	1.2	MR	MR
VC3543-B-2-1-1-B	VC2527A/VC2530C	2.7	1.6	MR	HR
VC3580-1-1-3-3-B	Shanhua 1/VC2528B	2.7	1.7	HR	MR
VC3580-1-2-3-3-B	Shanhua 1/VC2528B	2.7	1.5	MR	HR
V3476 (Ck)	CES1D-21	2.6	1.3	HS	HS
CV (%)		8	10		
LSD (.05)		0.36	0.25		

[z]CLS = *Cercospora* leaf spot; PM = powdery mildew; HR = highly resistant; MR = moderately resistant; HS = highly susceptible.

Table 15. High-yielding lines from the advanced yield trial (AYT) in the February and July 1984 plantings, AVRDC.

AVRDC Cross No.	Yield (t/ha)			First Harvest (%)		Disease Rating[z]	
	Feb.	July	mean	Feb.	July	CLS	PM
VC3117-7-2B-2-B	2.9	1.9	2.4	58	85	MS	MR
VC3301-2B-1-1-2B	2.9	1.6	2.2	57	81	MR	MR
VC3012-11-2B-1-B	2.6	1.9	2.2	61	82	HR	MR
VC3199A	2.6	1.6	2.1	60	86	MS	HR
VC2917-B-1-B-4-2B[y]	2.5	1.6	2.1	66	86	MR	MR
VC2770-B-15-1-B[x]	2.6	1.5	2.1	65	94	MR	MR
V3476 (Ck)[x]	2.4	1.5	1.9	57	87		
Mean of 30 entries	2.3	1.5	1.9	57	87		
CV (%)	10	13	11	15	10		
LSD (.05)	0.32	0.27	0.29	12	8		

[z]CLS = *Cercospora* leaf spot, PM = powdery mildew; HR = highly resistant; MR = moderately resistant; MS = moderately susceptible. [y]Has a shiny seed coat and is photoperiod-insensitive. [x]Has a shiny seed coat.

Table 16. Performance of 10 high-yielding lines from the elite yield trial (EYT) in the March and July 1984 plantings, AVRDC.

AVRDC No.	Yield (t/ha)			First Harvest (%)		Disease Rating[z]		1000-Seed
	March	July	mean	March	July	CLS	PM	Wt (g)
VC2768A	1.6	1.9	1.8	58	69	MR	MS	62
VC2755A	1.9	1.6	1.7	61	72	MR	MS	66
VC3061A[y]	1.6	1.9	1.7	56	67	MS	MR	56
VC2307A	1.4	2.0	1.7	52	73	MS	MR	43
VC2764B	1.6	1.8	1.7	53	77	MR	MS	57
VC2771A	1.8	1.5	1.7	64	76	MR	MR	59
VC1482E	1.6	1.7	1.7	57	75	MR	MS	48
VC2754A	1.4	1.8	1.6	49	79	MR	MR	60
VC3031A	1.6	1.6	1.6	62	76	MS	MR	50
VC2764C	1.5	1.7	1.6	52	74	MR	MS	60
V3476 (Ck)	1.4	1.4	1.4	60	84	HS	HS	48
Mean of 22 entries	1.5	1.6	1.5	53	77			54
CV (%)	21	15	18	23	6			5
LSD (.05)	0.37	0.29	0.33	16	6			3

[z]CLS was rated in summer and fall, and PM in spring and fall in the disease nurseries. HR = highly resistant; MR = moderately resistant; HS = highly susceptible; MS = moderately susceptible. [y]Photoperiod insensitive and dull seed coat.

Table 17. High-yielding lines from the 12th International Mungbean Nursery in March and July plantings, 1984, AVRDC.

AVRDC No.	Parentage or Cultivar Name	Yield (t/ha)			1st Harvest (%)		Disease Rating[z]		1000-Seed
		March	July	mean	March	July	CLS	PM	Wt (g)[y]
VC2768A	VC1482A/VC1628A	1.8	2.0	1.9	78	60	MR	MS	62
VC2764A	VC1481A/VC1628A	1.7	2.1	1.9	75	68	MS	MS	56
VC2768B	VC1482A/VC1628A	1.7	2.0	1.9	66	63	MS	MS	62
VC2750A[x]	VC1168D/VC1560A	1.5	2.1	1.8	69	71	MR	MR	49
VC1628A	CES1D-21/PHLV18	1.3	2.1	1.7	68	70	HS	HS	57
VC2755A	VC1177B/VC1647A	1.6	1.7	1.7	67	69	MR	MS	63
VC1562A[w]	BPI.glab.3/VC1394	1.3	2.0	1.7	65	68	MR	MR	56
VC2523A[x]	VC1209A/PHLV18	1.5	1.8	1.6	58	73	HS	MS	47
V2984	K I #5	1.8	1.2	1.5	81	82	HS	MS	38
V3476 (Ck)	CES1D-21	1.2	1.7	1.4	64	73	HS	HS	46
Mean of 20 entries		1.4	1.7	1.6	65	72			52
CV (%)		10	14	13	17	7			9
LSD (.05)		0.23	0.41	0.32	18	9			8

[z]CLS was rated in summer and fall, and PM in spring and fall in the disease nurseries. MR = moderately resistant; MS = moderately susceptible, HS = highly susceptible. [y]Average of March and July seasons. [x]Dull seed coat. [w]Insensitive to photoperiod.

In all the yield trials conducted, the number of pods per plant had a consistently high significant correlation with yield regardless of planting time (r varied from 0.28** to 0.59**). Similarly, the earlier the maturity, the higher the percentage of total yield at first harvest (r = −0.25** to −0.90**).

Conclusion

Selections with a yield potential of 3 t/ha and more combined with high levels of resistance to CLS and PM with different seed sizes and different seed coat luster were identified. Most of them were resistant to lodging and a few were also insensitive to photoperiod. A high level of synchronized maturity was achieved in a few selections. Some

of these outstanding selections will be included in the next IMN. A consistent and significant positive correlation between number of pods per plant and yield suggested that we could use number of pods per plant as the selection criteria to obtain high yield.

Performance of Breeding Lines under Minimum Management Input

Introduction

Mungbean is generally grown with minimum or no management input. Therefore, breeding lines with high yield potential adapted to such situations need to be developed. It is also necessary to understand whether the selections made under optimum inputs will be suitable for minimum or no-input situations.

Materials and Methods

As in 1983, 20 breeding lines and two check cultivars were used in the elite yield trial (EYT) with optimum input in the March and July plantings. Adjacent to this trial, also in March and in July, the minimum management-input trial was planted. A randomized complete block design with three replications was used. Planting dates, spacing, and plot size were the same as those of EYT. No management inputs were given, except thinning after emergence to adjust plant population density.

Results

The mean yield of 22 genotypes in optimum input was 1.5 t/ha in the March and 1.6 t/ha in the July plantings; while in the minimum input, it was 0.8 and 1.2 t/ha, respectively. The yield gaps between optimum input and minimum input in the March and July plantings were 47 and 16%, respectively (Fig. 1). The yield gap in the March planting was 31 percentage points higher than that of the July planting. Although the absolute yields of optimum input and minimum input in the 1983 trials were different in the March and July plantings, the yield gap in March 1983 was almost identical (31%) to that of the 1984 trials. In the July plantings the temperature was higher and moisture was not limiting which enabled an increase of about 61 to 94% yield over the March planting in the minimum input. The differences in mean yield in optimum input between the March and July plantings in both 1983 and 1984 were negligible although there was a year-to-year variation (Figs. 1 and 2).

As in 1983, a significant positive correlation was observed between the yields under optimum and minimum managements in 1984 (Fig. 3). Therefore, it is obvious that breeding for optimum and minimum inputs can be accomplished by selecting either of these conditions.

Selected breeding lines with high yield potential under optimum and minimum input trials are shown in Tables 18 and 19. Similarly, breeding lines with 25% or less yield reduction under minimum and optimum managements, when both season were considered, are given in Table 20. Among the entries evaluated, VC2754A and VC2771A appeared to be the best for wide adaptability. To confirm such conclusions they should be evaluated under diverse locations and environments.

The mean values of various agronomic characters in optimum and minimum managements are given in Table 21. Among the characters observed, the major character influenced was yield -34% reduction in minimum management compared to optimum management which can be easily traced to 31% reduction in number of pods per plant (Table 21).

Conclusion

A two-year (four seasons) study confirmed the findings that genotypes with a yield of more than 1 t/ha under minimum input are available. Also confirmed were the findings that selections under high-yielding management-input environment is also appropriate for the low-yielding minimum-input environment. Therefore, the project will be terminated.

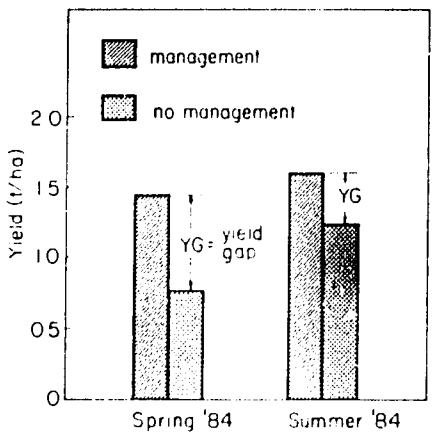


Fig. 1. Comparison of yields between optimum management and no-management in spring (March) and summer (July) 1984, AVRDC.

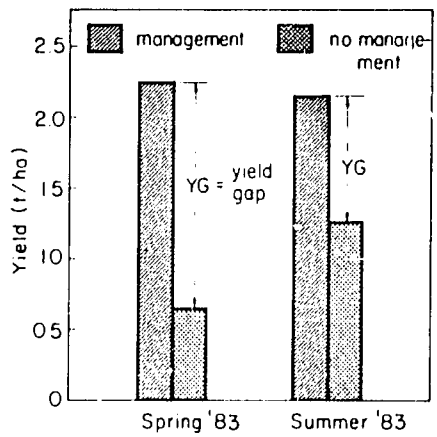


Fig. 2. Comparison of yields between optimum management and no-management in spring (March) and summer (July) 1983, AVRDC.

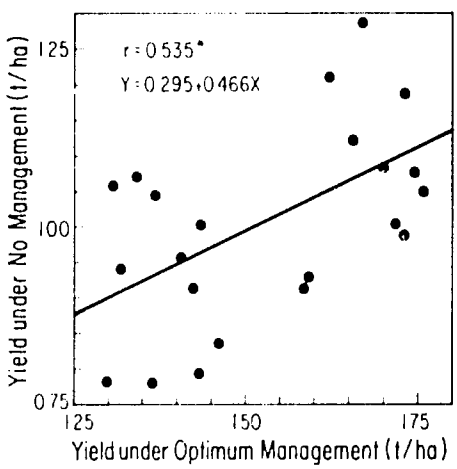


Fig. 3.
Relationship between mean yields of 22 mungbean lines under optimum and minimum managements in spring and summer 1984, AVRDC.

Table 18. High-yielding lines under optimum management input in the March and July plantings, 1984, AVRDC.

AVRDC No.	Yield (t/ha)						Yield Reduction (%)
	optimum management			minimum management			
	March	July	mean	March	July	mean	
VC2768A	1.6	1.9	1.8	0.1	1.2	1.1	0.7 (40)
VC2755A	1.9	1.6	1.7	0.7	1.3	1.0	0.7 (43)
VC3061A	1.6	1.9	1.7	0.9	1.5	1.2	0.5 (31)
VC2764B	1.6	1.8	1.7	0.9	1.3	1.1	0.6 (37)
VC2771A	1.8	1.5	1.7	1.1	1.4	1.3	0.4 (23)
VC1482E	1.6	1.7	1.7	0.9	1.4	1.1	0.5 (33)
VC2754A	1.4	1.8	1.6	1.0	1.4	1.2	0.4 (25)
V3476 (Ck)	1.4	1.4	1.4	0.5	1.0	0.8	0.6 (45)
Mean of 22 entries	1.5	1.6	1.5	0.8	1.2	1.0	0.5 (34)
CV (%)	21	15	18	31	11	20	
LSD (.05)	0.37	0.29	0.33	0.40	0.23	0.32	

Table 19. High-yielding lines under minimum management input in March and July plantings, 1984, AVRDC.

AVRDC No.	Yield (t/ha)						Yield Reduction (%)
	optimum management			minimum management			
	March	July	mean	March	July	mean	
VC2771A	1.8	1.5	1.7	1.1	1.4	1.3	0.4 (23)
VC2754A	1.4	1.8	1.6	1.0	1.4	1.2	0.4 (25)
VC3061A	1.6	1.9	1.7	0.9	1.5	1.2	0.5 (31)
VC3031A	1.6	1.6	1.6	1.0	1.3	1.2	0.5 (28)
VC1482E	1.6	1.7	1.7	0.9	1.4	1.1	0.5 (33)
VC2764B	1.6	1.8	1.7	0.9	1.3	1.1	0.6 (37)
VC2768A	1.6	1.9	1.8	0.9	1.2	1.1	0.7 (40)
V3476 (Ck)	1.4	1.4	1.4	0.5	1.0	0.8	0.6 (45)
Mean of 22 entries	1.5	1.6	1.5	0.8	1.2	1.0	0.5 (34)
CV (%)	21	15	18	32	11	20	
LSD (.05)	0.37	0.29	0.33	0.40	0.23	0.32	

Table 20. Breeding lines with least yield reduction under minimum management input in March and July plantings, 1984, AVRDC.

AVRDC No.	Yield (t/ha)						Yield Reduction (%)
	optimum management			minimum management			
	March	July	mean	March	July	mean	
VC2719A	1.2	1.4	1.3	0.9	1.2	1.1	0.2 (19)
VC2763A	1.2	1.4	1.3	0.8	1.3	1.1	0.3 (20)
VC2771A	1.8	1.5	1.7	1.1	1.4	1.3	0.4 (23)
VC2802A	1.3	1.4	1.4	0.8	1.3	1.1	0.3 (23)
VC2754A	1.4	1.8	1.6	1.0	1.4	1.2	0.4 (25)
V3476 (Ck)	1.4	1.4	1.4	0.5	1.0	0.8	0.6 (45)
Mean of 22 entries	1.5	1.6	1.5	0.8	1.2	1.0	0.5 (34)
CV (%)	21	15	18	32	11	20	
LSD (.05)	0.37	0.29	0.33	0.40	0.23	0.32	

Table 21. Comparison of mungbean yields and agronomic characters between optimum and minimum management in the March and July 1984 plantings, AVRDC.[z]

Characters	Yield (t/ha)						Mean Difference (%)
	optimum management			minimum management			
	March	July	mean	March	July	mean	
Grain yield (t/ha)	1.5	1.6	1.5	0.8	1.2	1.0	0.5 (34)
Plant height (cm)	52	64	58	56	67	62	-4 (7)
Days to 50% flowering	46	39	43	45	42	44	-1 (2)
Days to 50% maturity	65	58	62	66	61	64	-2 (3)
Days to mean maturity	83	74	79	82	72	77	2 (3)
% 1st harvest	53	77	65	57	90	72	-7 (11)
Pods/plant	11	16	13	7	12	9	4 (31)
Seeds/pod	10	11	11	11	11	11	-0.3 (3)
1000-seed weight (g)	52	56	54	54	55	55	-1 (2)

[z]Data are means of the same 22 entries from separate trials.

Evaluation of Breeding Lines in Various Yield Trials for Disease Resistance

Introduction

Generally, yield trials are conducted with proper management inputs, including disease control. Therefore, it is difficult to evaluate them for disease reaction. To evaluate the breeding lines for diseases, a separate experiment in different seasons was conducted without disease control measures.

Materials and Methods

From the preliminary, intermediate, advanced, elite, and interna-tional mungbean nursery trials, a total of 307 lines in February and 423 lines in July and September plantings were screened for *Cercospora* leaf spot (CLS) and powdery mildew (PM) resistance. The plantings were made on February 28, July 12, and September 11, 1984. Each entry was planted on a single 2-m-long row with 0.5 m between row spacings. Two replications were used. Resistant check V2773 was planted in every fifth (February and September plantings) or in every seventh row (July planting). The CLS-and PM-susceptible check V1944 was planted in February and September, and the CLS-susceptible check, V2010, was planted in July in a band 1 m in width across the rows between two columns of test lines.

In February, July, and September, PM was rated, and in July and September CLS was rated on the following rating scale: 1 to 2 = highly resistant, resistance better than V2773; 2.1 to 3.0 = moderately resistant, resistance similar to V2773; 3.1 to 4.0 = moderately susceptible, resistance below V2773 but worse than V1944 or V2010; 4.1 to 5 = resistance similar to or worse than V1944 or V2010.

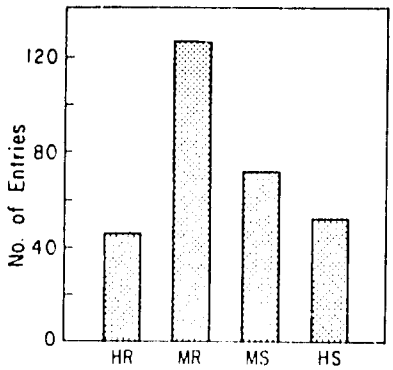
Results

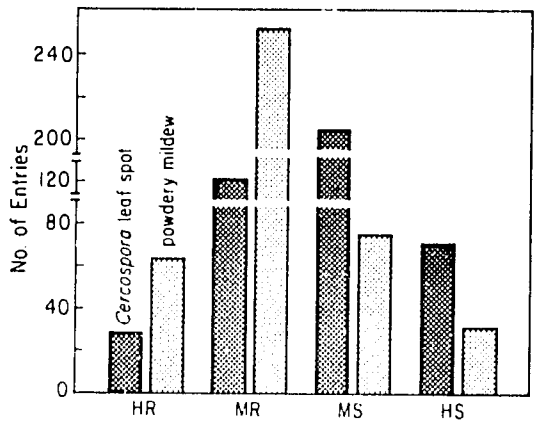
In the February screening, 15% of the 307 lines evaluated were rated highly resistant and 41%, moderately resistant to PM (Fig. 4). In the July planting, CLS was the most severe disease. Out of 423 lines screened about 7% were rated highly resistant to it and 15% were considered highly resistant to PM (Fig. 5). However, in the September planting, PM was the most serious disease. Only 12% of the 423 lines were rated highly resistant to it, but 10% were rated as highly resistant to CLS (Fig. 6). February and September were the best seasons to evaluate for PM; and July, for CLS.

Among the 306 entries evaluated in all the three seasons put together, six entries were highly resistant to both CLS and PM, and 70 entries were either highly or moderately resistant to both the diseases (Table 22). Among them four breeding lines gave more than 2 t/ha in the March and three gave 1.7 to 1.8 t/ha in the July planting (Table 23). The total yield at first harvest was more than 80% in three high-yielding entries.

Conclusion

Improved levels of resistance to CLS or PM or both have been incorporated in more new breeding lines. There appears to be a new source of resistance to CLS and PM which needs to be investigated. The potential to improve the resistance to both diseases through pyramiding of genes from different sources need to be explored.





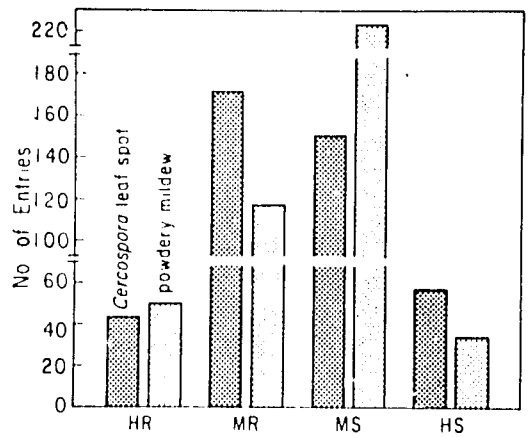


Fig. 4. (above)
Reaction of various entries to powdery mildew in the February 1984 screening, AVRDC.

Fig. 5. (upper right)
Disease reaction of various entries in the July 1984 screening, AVRDC.

Fig. 6. (right)
Disease reaction of various entries in the September 1984 screening, AVRDC.

Table 22. Frequency distribution of disease ratings of 298 breeding lines and eight accessions tested over three seasons in 1984, AVRDC.[z]

Powdery Mildew (PM)	*Cercospora* Leaf Spot (CLS)				Total
	HR	MR	MS	HS	
HR[y]	5/1[x]	7	17	2	31/1
MR	11	52	73/1	8	144/1
MS	3	40/2	55	12	110/1
HS	1	1	8/1	3/3	13/4
Total	20/1	100/2	153/2	25/3	298/8

[z]Since preliminary yield trial-III was conducted in the July and September seasons, it was excluded in this table. [y]HR = highly resistant; MR = moderately resistant; MS = moderately susceptible; HS = highly susceptible. [x]Breeding lines/accessions.

Table 23. Breeding lines highly resistant to both CLS and PM, 1984, AVRDC.

Selection No.	Parentage	Yield (t/ha)			1st Harvest (%)	
		March	July	mean	March	July
VC1560D	BPI glab.3/VC1301	1.2	1.4	1.3	42	83
VC2719-B-18-B-3-B	Shanhua 1/VC1163A	2.7	1.3	2.0	53	82
VC3528-2B-3-B-2[z]	VC1560D/VC2533A	2	1.7	2.1	43	81
VC3732-B-3-B-1	Shanhua 1/VC2530C	2.0	1.8	1.9	48	79
VC3748-3-B-B-1-2-B[z]	VC1562A/VC2527A	2.3	1.7	2.0	43	64

[z]Insensitive to photoperiod.

Photoperiodic Response of Breeding Lines

Introduction

Among the environmental factors, photoperiod and temperature influence the range of adaptation of mungbean cultivars. To have a fairly wide adaptability in mungbean, therefore, photoperiod insensi-tivity will be one of the requirements. Through disruptive seasonal selection employed at AVRDC, the highly photoperiod-sensitive lines were discarded. In order to determine the photoperiodic response of the advanced breeding lines, they were evaluated in the following experiment.

Materials and Methods

From various yield trials 229 entries were planted on September 11, 1984 under 16 hr photoperiod and in another field under natural photoperiod. Each entry was planted on a 2-m-long single row with a spacing of 0.5 m between rows. V1380, V1388, and V4281 were used as the photoperiod-sensitive checks, and V3726 (Varsha) as the photoperiod-insensitive check. Days to flowering were recorded when 50% of the plants in a plot started flowering. The delay in days to flowering was used to determine the photoperiod-sensitivity score.

Results

Photoperiod-sensitivity scores of the breeding lines ranged from 0 to 4. Among the 229 lines evaluated 46% were insensitive to photoperiod (sensitivity score 0) (Fig. 7).

Among the photoperiod-insensitive lines; five had high yield potential combined with high level of resistance to either *Cercospora* leaf spot (CLS) or powdery mildew (PM) (Table 24).

Conclusion

Majority of the AVRDC breeding lines were less sensitive to photo-period. Selected entries with photoperiod insensitivity were both high-yielding and resistant to either CLS or PM. These findings need to be evaluated in diverse environments to explore their potential.

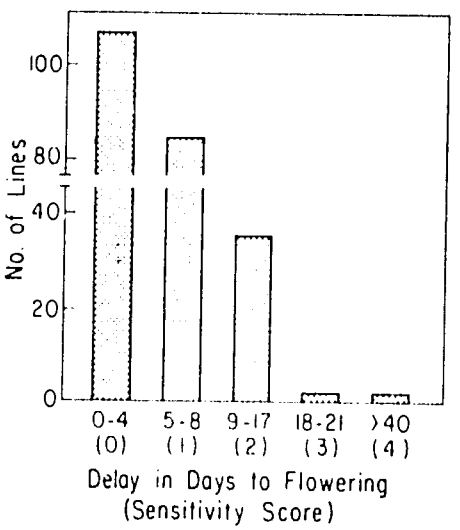


Fig. 7.
Frequency distribution of delay in number of days to flowering under 16 hr compared to that of natural photoperiod in the September 1984 planting, AVRDC.

Table 24. Breeding lines insensitive to photoperiod and highly resistant to either *Cercospora* leaf spot or powdery mildew, 1984, AVRDC.

Selection No.	Parentage	Yield (t/ha)			1st Harvest (%)		Disease Rating[z]	
		March	July	mean	March	July	CLS	PM
VC1131B	VC1000/EG-MG-16	2.4	1.6	2.0	61	89	HR	MR
VC2985-3-2B-1-B	VC1000A/VC1163B	2.8	1.8	2.3	49	89	HR	MR
VC3580-1-2-3-3-B	Shanhua 1/VC2528B	2.7	1.3	2.0	47	84	MS	HR
VC3687-B-1-B-1	VC2527A/VC2770A	2.6	1.5	2.1	60	87	HR	MR
VC3751-3-B-2-2-B	VC1647B/VC2719A	2.6	1.9	2.3	45	66	MR	HR

[z]CLS = *Cercospora* leaf spot; PM = powdery mildew; HR = highly resistant; MR = moderately resistant; HS = highly susceptible; MS = moderately susceptible.

International Cooperation

In 1984 we distributed 824 breeding lines and 1,507 accessions to 90 cooperators in 28 countries. A total of 108 seed packets were distributed. The following are the cooperators' reports.

Australia

A report received in June 1984 from Dr. Imrie stated that 70% of the total mungbean area (940 ha), which was an increase of 30% over 1982-83, was planted to cv. King in the Northern Territories. The yield of King is 1 t/ha, which is better than that of Berken, a local cultivar (0.46 t/ha). There is an additional 6,000 ha planted to King in Central Queensland and SE Queensland. Yields in the 1983-84 season were 2.3 to 2.9 t/ha.

Ethiopia

All our entries were reported susceptible to halo blight and lower yielding than the local check M1134.

Fiji

VC1007-14-1-5B and VC1160-1-1-2B were released as Station 25 and Station 27, respectively, and the seeds distributed to the farmers. Preliminary reports indicated that VC1560D also appeared to be promising.

Indonesia

Among nine entries evaluated the newly released AVRDC entry VC1089A (Manyar) was the highest yielder with 1.6 t/ha (Table 25). In another trial conducted at Yogyakarta, VC2768A gave a better yield of 1.5 t/ha than the local check, Merak (1.4 t/ha) (Table 26).

Israel

Preliminary reports indicated that VC1973A was promising with high yield potential.

Nepal

Among 23 entries tested, VC1647B yielded 0.9 t/ha compared to the check Pusa Baishaki's 0.7 t/ha. The farmers who visited the plot favored VC1647B over the others (Table 27).

Table 25. Performance of selected AVRDC mungbean lines at Alai Hilir, 1983-1984.[z]

AVRDC No.	Yield (t/ha)	Pods/Plant	1000-Seed Wt (g)
VC1973A	1.5	17	52
VC2719A	1.3	18	56
VC2307A	1.2	19	50
V3476	1.1	14	55
Manyar (VC1089A)	1.6	23	47
Mean of 9 entries	1.2	16	55
CV (%)	30		
LSD (.05)	0.52		

[z]Sown: Dec. 3, 1983; harvested: 1/27, 2/1, 2/8, 2/15, 2/22, 2/29, 1984; plot size: 12m^2 (4 rows × 6m × 0.5m), no. of replications: 4; population density: 200,000 plants/ha. Cooperator: Asmar Jaya, Pilot Project on Integrated of Soya and Food Crops Development. Elevation: 56 m; season: wet season; mean temperature during the crop season: 25.6°C (min), 34.4°C (max); rainfall during the crop season: 789.0 mm.

Table 26. Performance of selected AVRDC mungbean lines at Yogyakarta, Indonesia, 1983-84.[z]

AVRDC No.	Yield (t/ha)	Days to 1st Maturity	1000-Seed Wt (g)
VC2768A	1.5	62	61
VC1974A	1.4	61	56
Merak (Ck)	1.4	61	65
VC2778A	1.3	62	52
VC1973A	1.3	61	59
Mean of 10 entries	1.2	62	53

[z]Sown: Nov. 9, 1983; harvested: (?), Jan. 30, 1984 (twice); plot size: 16 m^2 (5 rows × 8 m × 0.4 m); population density: 330,000 plants/ha. Cooperators: Sugiharto and C. W. Lin; institute: Bandung Agriculture Demonstration Center, District of Gunung Kidul, the Special Province of Yogyakarta; season: 1st crop season.

Table 27. Performance of selected AVRDC mungbean lines at Lalpati, Nepal, 1983.[z]

AVRDC No.	Yield (t/ha)	Days to 1st Maturity	1000-Seed Wt (g)
VC1647B	0.9	52	60
VC1973A	0.9	54	50
VC2755A	0.7	58	40
V3726	0.7	49	60
Pusa Baishaki (Ck)	0.7	52	50
Mean of 23 entries	0.5		

[z]Sown: April 9, 1983, harvested: June 18 and July 5, 1983, plot size: 4.8 m^2 (4 rows × 3 m × 0.4 m); no. of replications: 3; population density: 250,000 plants/ha. Cooperators: D. R. Wagle, K. B. Kadayat, A. Jaeckle & U. Scheuermeier, Tinau Watershed Project, Agriculture Section. Latitude: 27°50'N; longitude: 83°40'E, elevation: 700 m, season: pre-monsoon season; mean temperatures during the crop season: 18.5°C (min), 30.5°C (max), rainfall during the crop season: 985.9 mm.

Pakistan

In one of the trials among the entries evaluated, V4800 (cv. Type 1 from India) had a better level of resistance to mungbean yellow mosaic virus (MYMV) than the already known sources of resistance to MYMV, such as V3484 (6601), V2772 (ML-1), and V2272 (ML-5).

Philippines

V[illegible]1163-2-3-4-2B was released as BPI-MG-1. It is a cross between EG-MG-4 and ML-6. Prior to its release it was evaluated at 10 locations in the Philippines through 12 dry-season and 15 wet-season trials. The total yield can be harvested in two pickings. It combines moderate

resistance to *Cercospora* leaf spot (CLS), powdery mildew (PM), and mungbean rust. With an average yield of 1.1 and 1.4 t/ha in the dry and wet seasons, respectively, it is recommended for both seasons. The 1000-seed weight is about 56 g and the seed is shiny.

In a trial at Leyte which evaluated 24 entries V2984, VC1973A, and VC2768A significantly outyielded RES Acc. #9 (Table 28) In another trial conducted at Palawan, the AVRDC entries were on par with the local checks. Since the coefficient of variation is 95% the data were of little value (Table 29).

Table 28. Performance of selected AVRDC mungbean lines at Leyte, Philippines, 1984.[z]

AVRDC No.	Yield (t/ha)	Plant Height (cm)	Pods/Plant	1000-Seed Wt (g)
V2984	1.8	84	23.9	38
VC1973A	1.7	72	18.9	67
VC2768A	1.7	65	16.0	62
VC2764A	1.5	69	20.8	60
RES Acc. #9 (Ck)	1.1	69	29.4	49
Mean of 24 entries	1.4			
CV (%)	76			
LSD (.05)	0.50			

[z]Sown: April 18, 1984; harvested: June 11, 18 and 26, 1984; plot size: 12 m^2 (4 rows × 6 m × 0.5 m); no. of replications: 4; population density: 400,000 plants/ha. Cooperator: P. C. Tobias, Ministry of Agriculture & Food, Romualdez Experiment Station, Babatngon, Leyte. Elevation: 10 m; season: summer; mean temperatures during the crop season: 27°C (min), 36°C (max); rainfall during the crop season: 313.3 mm.

Table 29. Performance of selected AVRDC mungbean lines at Palawan, Philippines, 1983.[z]

AVRDC No.	Yield (t/ha)	Days to 1st Maturity	1000-Seed Wt (g)
VC1628A	1.1	56	55
VC1560D	1.1	55	60
VC2764A	0.9	53	60
VC1973A	0.8	61	60
Local Green	0.9	64	42
Local Yellow	0.9	64	53
Mean of 6 entries	0.9		
CV (%)	95		
LSD (.05)	NS[y]		

[z]Sown: Feb. 26, 1983; harvested: (?); plot size: 8.74 m^2; no. of replications: 2; population density: 104,405 plants/ha; season: dry. Cooperator: Fol Sariaco, PNAC, Aborlan, Palawan. [y]Not significant.

International Mungbean Nursery (IMN)

The 11th IMN had nine cultivars from national programs and 11 AVRDC breeding lines. A total of 47 sets were distributed to 22 countries. Data were received from 31 cooperators in 14 countries; three data sets were incomplete and could not be analyzed.

For the 12th IMN in 1984, six cultivars and 14 breeding lines were included. A total of 64 sets were sent to 60 cooperators in 30 countries.

Results from Swaziland showed that VC2768A had the highest yield of 3.1 and 3.5 t/ha and the highest average yield. The mean yield in 29 locations was 1.1 ± 0.6 t/ha (ranging from 0.1 t/ha in China to 2.5 t/ha in Swaziland). At least 13 locations reported yields of more than 1 t/ha (Fig. 8). VC2768A and VC2764A were the highest yielders in five locations; and VC1973A and VC2778A in three locations. VC2755A, V2272, and V2984 were the highest yielders in two locations (Table 30). The combined analysis and the details will be published, in a separate IMN report.

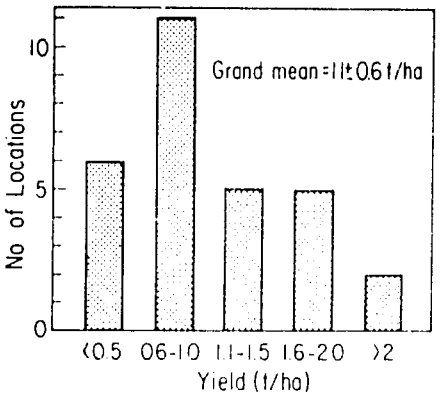


Fig. 8.
Frequency distribution of mean yields in the International Mungbean Nursery trials in 29 locations in different countries.

Table 30. Yield and disease ratings of the 11th IMN trials in 29 locations in 14 countries.[z]

Country	Mean Yield (t/ha)	Entry Yield (t/ha)		Check Cultivars and Yield (t/ha)	Mean of Disease Rating[y]		
		highest	lowest		CLS	PM	others
Burma	0.4	0.6 (VC2755A)	0.1 (V3092)	–	–	–	–
Taiwan, China	2.0	2.3 (VC2764A)	1.6 (V1381)	–	–	–	–
Taiwan, China	1.7	2.7 (VC2768A)	0.7 (V3092)	–	–	–	–
Beijing, China	1.9	2.6 (VC1973A)	1.2 (V3404)	–	–	–	Virus 2.2
Beijing, China	0.1	0.2 (V3404)	0.03 (VC2719A)	–	–	–	–
Indonesia	1.6	2.4 (VC2764A)	1.0 (V3726)	–	3.7	–	Virus 1.6
Indonesia	1.0	1.4 (VC1562A)	0.6 (V2272)	0.8	–	–	–
Indonesia	0.4	0.9 (V2272)	0.1 (VC1562A)	0.1	1.8	–	–
Indonesia	1.0	1.2 (VC1482C)	0.6 (V2010)	–	2.8	–	–
Korea	0.8	1.2 (VC2778A)	0.5 (V2272)	–	2.0	2.3	Virus 1.8
Malaysia	0.6	0.9 (VC2523A)	0.4 (VC1482C)	–	2.7	–	–
Malaysia	1.3	1.5 (V2984)	0.9 (V1968)	–	2.1	–	–
Mauritius	0.5	0.8 (VC1628A)	0.3 (V1968)	0.6	–	–	–
Pakistan	1.0	1.3 (VC2778A)	0.4 (V2272)	0.7	–	–	–
Pakistan	1.1	1.7 (V3726)	0.7 (VC1628A)	0.8 (M28)	–	–	–
				0.5 (6601)	–	–	–
Pakistan	2.0	2.5 (VC2768A)	1.2 (V2272)	1.3 (M28)	–	–	–
				1.1 (71-17)	–	–	–
Philippines	0.7	1.1 (V2984)	0.4 (V2010)	0.7, 0.6	2.7	–	–
Philippines	0.9	1.4 (VC1973A)	0.6 (V3476)	–	1.3	–	–
Sri Lanka	0.7	1.2 (VC2778A)	0.2 (V2010)	0.9, 0.7	–	–	–
Swaziland	1.5	2.3 (VC2755A)	1.0 (V3404)	2.1	1.9	–	Virus 1.0
							MYMV 0.6
Swaziland	2.5	3.5 (VC2768A)	1.5 (V2272)	2.7	2.8	1.2	Virus 1.5
Swaziland	2.4	3.1 (VC2768A)	1.9 (V3476)	2.6	2.2	–	Virus 0.3
							MYMV 0.2
Tanzania	1.5	1.7 (VC2764A)	1.3 (V2984)	1.5 (Nuru)			
				1.6 (Imara)			
Thailand	1.5	1.9 (VC2768A)	1.1 (V2010)	1.6, 1.4	1.9	–	–
Thailand	0.3	0.5 (V2272)	0.1 (VC2719A)	–	–	–	–
Thailand	0.9	1.3 (VC2764A)	0.5 (V1968)	–	–	–	–
Thailand	1.0	1.3 (VC1973A)	0.8 (VC1562A)	–	–	–	–
U.S.A.	0.9	1.4 (VC2764A)	0.5 (VC2719A)	–	–	–	–
U.S.A.	0.3	0.5 (V3476)	0.1 (V3404)	–	–	–	–
Mean	1.1 ± 0.6						

[z]IMN = International mungbean nursery. [y]For *Cercospora* leaf spot (CLS) and powdery mildew (PM): 1 = highly resistant and 5 = highly susceptible. For others: 0 = highly resistant and 5 = highly susceptible

Mungbean Entomology

In 1984, as in the past years, our major research activities in entomology emphasized resistance to beanflies. Before his departure from AVRDC, Dr. C. S. Ahn succeeded in crossing bruchid-resistant blackgram and mungbean, hence, we also screened interspecific cross progeny for bruchid resistance.

Third Screening of Mungbean Accessions for Resistance to Beanflies

Introduction

In late 1983, 222 mungbean accessions were screened which were selected from the 1982 preliminary tests for resistance to beanflies, *Ophiomyia phaseoli*, *O. centrosematis*, and *Melanagromyza sojae* (Diptera: Agromyzidae); in Indonesia. Out of these accessions only eight, which had the lowest beanfly-related plant mortality, were selected. These eight accessions were screened with one susceptible and one resistant checks at AVRDC to confirm their resistance.

Materials and Methods

A 0.03 ha piece of land away from areas of frequent insecticide use, was rototilled, applied with basal fertilizers, and worked into 0.75 m wide beds. These beds were further divided into 5 m long plots. Seeds of each mungbean accession were sown on three randomly selected plots. The crop was grown according to routine cultural practices, except that no insecticide was sprayed. At 25 and 40 days after sowing, 20 plants at random were uprooted, their stems cut open, and the number of larvae and pupae found within each plant recorded. The number of plants with visible beanfly damage in each accession was also recorded. Insect count and plant damage data were analyzed by Duncan's Multiple Range Test.

Results

The results of insect count-and plant damage are summarized in Table 1. Four accessions, V1160, V4281, V5784, and V5973 had the lowest number of insects inside the stem. In V1160, plant damage was minimum in both screenings; and in V4281, our standard resistant check, no damage was detected. V1160, a *Vigna radiata* var. *glabratum* accession, was the least damaged entry. It also had the lowest plant mortality due to beanflies in the second screening at Indonesia in 1983.

Conclusion

It will be worthwhile to introduce the beanfly resistance of V1160 into the agronomic cultivar of mungbean, since its level of resistance is greater than that of our standard resistant

check, V4281, both at AVRDC and in Indonesia. This accession is also rarely damaged by foliage-feeding insects.

Table 1. Performance of selected mungbean accessions during the third screening for beanfly resistance.[z]

Accession No.	No. of Beanfly Larvae + Pupae per 20 Plants		Damaged Plants (%)	
	16 October	29 October	16 October	29 October
V1160	2.0b	0.5c	25.7b	30.0d
V3741	8.0a	17.3a	56.7ab	95.0a
V4281	1.3b	1.5c	61.0ab	47.5cd
V4900	8.3a	5.0c	80.0a	75.0ab
V4920	2.0b	4.7c	49.0ab	63.3bc
V4940	5.0ab	6.3bc	58.3ab	63.3bc
V4947	2.3b	4.3c	58.3ab	68.3bc
V5784	1.7b	3.3c	50.0ab	56.7bc
V5973	1.7b	3.7c	46.7ab	63.3bc
Tainan #3	5.0ab	11.3ab	60.0ab	78.3ab

[z]Planting date: Sept. 20, 1984; data are means of three replicates; means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Screening of Segregating Populations for Resistance to Beanflies

Introduction

In autumn 1979 three mungbean accessions with moderate levels of resistance to beanflies were found. In 1980, 1981, and 1982 our mungbean breeder made a series of crosses involving a beanfly resistance source and high-yielding and disease-resistant breeding lines. During the past three years the segregating materials at AVRDC, Indonesia, and Thailand have been screened. Since beanfly population pressure is very high in Indonesia and Thailand, the susceptible or less resistant plants are killed by these insects, which makes it easier to select the resistant plants.

Therefore, in the past greater emphasis was placed on screening of segregating populations in Indonesia and Thailand. However, due to logistical and storage difficulties, the selected germplasm could not be utilized for further crossing or advanced screening. In 1984, therefore, screening work was moved back to AVRDC where, in autumn, a series of segregating populations from F3 to F7 involving all crosses were screened. The selection procedure was also modified.

Materials and Methods

The land was rototilled, applied with basal fertilizer, and worked into 0.75 m wide beds. The seeds were sown on the bed as single-row plots of various lengths, depending upon the nature of the experiment and the amount of seeds available. The following segregating materials were screened in 1984:

Cross series	Generation	No. of entries
1 autumn 1980	F7	23
2 autumn 1981	F5	52
3 autumn 1982	F4	59
	F3	59

Seeds of each progeny were bulked up to F5. At F6 we planted the population in the field and with the help of a plant breeder, selected the plants in each cross with good agronomic characters. Seeds of selected plants were bulked individually; and in the next beanfly season, half of the seeds of each plant were planted in a replicated screening trial in the field, while the remaining half were saved. Plants are sampled at 25 and 35 days after germination and evaluated for beanfly resistance by cutting open each plant. The seeds of entries with the least damage are then multiplied and distributed to interested parties. The procedure is further illustrated in Fig. 1.

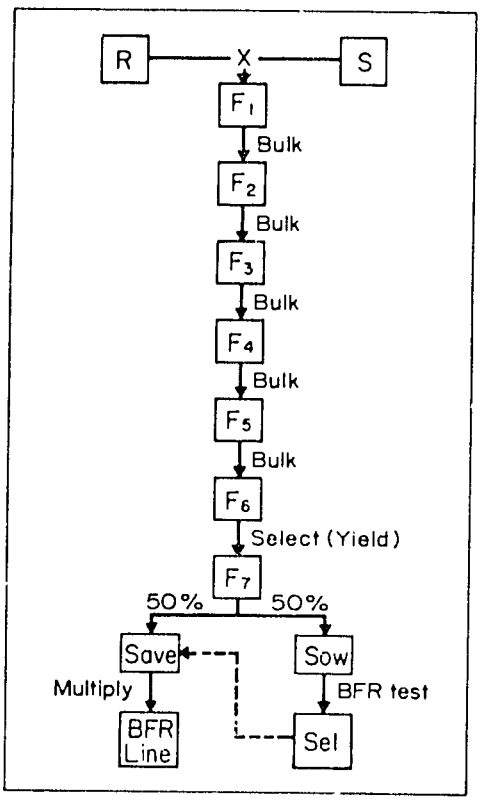


Fig. 1.
Breeding and selection scheme for beanfly resistance in mungbean.

Results

In autumn 1984, 90 plants from F7 were selected with good agronomic characters. The seeds of each plant were bulked and will be screened for beanfly resistance in 1985. The remaining segregating materials were also bulked and will be planted in spring 1985 to advance the generation and to screen for resistance in autumn 1985.

The Mechanism of Beanfly Resistance in Selected Mungbean Accessions

Introduction

In 1977-80, three mungbean accessions with moderate levels of resistance to beanflies were found. A resistance breeding program was initiated and the characteristics of this resistance mechanism were studied. Our early work in 1982-83 indicated that beanflies feeding on resistant accessions had a longer larval stage than those feeding on susceptible entries.

This indicated the possibility of antibiosis. In 1984, one test was conducted to study whether these plants, especially their unifoliate leaves which are first attacked by beanflies, had any antibiotic action against lepidopterous insects, such as *Porthesia taiwana* and *Heliothis armigera*, that feed on mungbean leaves.

Materials and Methods

Three beanfly-resistant accessions; V3495, V2396, and V4281 and two susceptible accessions, V2184 and V3428, were grown in seedling flats containing soil and compost mixture placed in the greenhouse. The unifoliate leaves of these plants were used for the feeding experiment. The larvae of *P. taiwana* and *H. armigera* were collected from the fields and maintained on mungbean leaves in a laboratory at 25°C and 65% RH. The pupae were confined in a chamber lined with rough tissue paper. A tomato plant was placed inside the chamber with the *H. armigera*. After emergence, the adult females laid eggs on the paper. All eggs were collected and placed on moist filter paper in a petri dish until they hatched. First instar larvae were used for the feeding study.

Two unifoliate leaves of each accession were placed on a moist filter paper in each of five petri dishes, and 4 to 10 first-instar larvae were released on the leaves. Each petri dish represented one replicate. Petri dishes were maintained at 25°C and 65% RH. Once every day the feeding activity of the insects was observed, and fresh leaves were placed at intervals to sustain larval feeding until pupation. At each observation, the number of live and dead larvae and pupae in each replicate was also recorded. Larval mortality and pupation percentage were analyzed by Duncan's Multiple Range Test.

Results

The results of insect mortality and pupation rates are presented in Table 2 for *P. taiwana* and in Table 3 for *H. armigera*.

Table 2. Mortality and pupation of *P. taiwana* fed on beanfly-resistant and susceptible mungbean accessions.[z]

Accession No.[y]	Progressive Mortality (%) at Days after Hatching						Pupation (%)
	5	10	15	20	25	30	
V2184 (S)	8.3	12.5	12.5b	12.5b	21.8b	37.5b	24.8a
V3428 (S)	0.0	0.0	10.0b	16.3b	24.5b	44.0b	30.0a
V3495 (R)	2.5	9.0	15.3b	33.3b	54.5a	66.5ab	0.0b
V2396 (R)	0.0	12.5	23.8b	38.3b	56.3a	59.3ab	3.3b
V4281 (R)	12.5	22.5	69.5a	74.5a	74.5a	74.5a	0.0b

[z]Data are means of five replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test. [y](S) = beanfly-susceptible; (R) = beanfly-resistant.

Table 3. Mortality and pupation of *H. armigera* fed on beanfly-resistant and susceptible mungbean accessions.[z]

Accession No.[y]	Progressive Mortality (%) at Days after Hatching				Pupation (%)
	5	10	15	20	
V2184 (S)	15	35b	40b	55	40
V3428 (S)	10	21b	36b	46	39
V3495 (R)	10	35b	50ab	55	30
V2396 (R)	15	40b	60ab	60	15
V4281 (R)	25	80a	80a	80	5

[z]Data are means of five replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test. [y](S) = beanfly-susceptible; (R) = beanfly-resistant.

Porthesia larvae feeding on the unifoliate leaves of beanfly-resistant accessions suffered relatively greater mortality than those feeding on susceptible ones. Among three resistant accessions, V4281 showed consistently greater levels of resistance than the other two. *Porthesia* feeding on V4281 had significantly higher mortality than the susceptible entries at each interval and significantly greater mortality than other resistant accessions at two out of three observations. Insect mortality was greatest on V4281 between 15 to 20 days after hatching.

The pupation rate of insects fed on beanfly-resistant accessions was significantly lower than that of insects fed on susceptible entries. In fact in V4281 and V3495, all insects died at prepupation stage.

Similar results were obtained with *H. armigera*. However, in this case only accessior V4281 showed antibiotic activity; the two other resistant entries were in most cases, at par with susceptible entries. On V4281, larval mortality was greatest 10 days after hatching. Pupation was considerably reduced in insects fed on V4281. Because of considerable larval mortality very few larvae remained in V4281 until pupation, whereas a greater number of them were alive in the susceptible accessions.

It must be emphasized here that in a similar study with *Spodoptera exigua*, no statistically significant results were obtained when insects were fed on the same resistant and susceptible accessions.

Conclusion

Beanfly-resistant accession V4281 showed considerable antibiosis to *Porthesia taiwana* and *Heliothis armigera* when the larvae of these insects were fed on unifoliate leaves of V4281 and susceptible mungbean accessions.

Screening of Interspecific Cross Segregating Materials for Resistance to Bruchid

Introduction

In 1979-80 two blackgram accessions, VM2011 and VM2164, were found to be moderately resistant to bruchid species, *Callosobruchus chinensis* (Coleoptera: Bruchidae). During 1981-82 our mungbean breeder perfected the technique of crossing these materials with mungbean. In 1983, he successfully crossed VM2164 with several advanced breeding lines of mungbean, and the resultant F2s and backcross progeny were sent to us for insect-resistance screening.

Materials and Methods

A total of 113 lines, comprising 105 interspecific hybrids and eight parents were screened for resistance to *C. chinensis*. The number of seeds per entry ranged from 1 to 235 and all seeds were used in testing.

The insects used in this screening were reared on mungbean at 30°C and 70% RH for three generations. Seeds of each entry were confined in glass vials (2.5 cm diam. × 12 cm height) and five pairs of 1-to 3-day-old adults were released over the seeds. The vials were covered with muslin cloth and maintained at 30°C and 70% RH.

Ten days after release, the adult insects were removed from the seeds and the number of eggs laid on the seeds were recorded. The seed samples were transferred back to the incubator; and three weeks later, the number of emerging first-generation adults were recorded. Simultaneously, the number of undamaged and bruchid-damaged seeds were also recorded.

Results

The insect laid eggs on all entries. The number varied from 2 to 392 eggs/sample. Thus, none of the entries had any oviposition-deterrent effect.

The number of second-generation adults varied from 0 to 244/sample. Twenty entries (including resistant parents and V4997 which is easy to cross with blackgram but which was never tested before) were free of adults although the insects laid eggs on the seeds. The performance of these entries is summarized in Table 4. The additional 20 entries had emerging first-generation adults, but these entries contained various levels of damaged and undamaged seeds. The performance of these entries is summarized in Table 5. Seventy-seven lines had

Table 4. Performance of selected mungbean lines with no emerging first-generation *C. chinensis* adults.[z]

Line No.	No. of Eggs Laid	No. of Seeds		Damaged (%)	No. of Emerging Adults
		damaged	undamaged		
IVC0021-4	8	0	1	0	0
IVC0023-15	127	0	91	0	0
IVC0023-18	38	0	17	0	0
IVC0023-19	109	0	148	0	0
IVC0026-6	35	0	9	0	0
IVC0029-1	16	0	4	0	0
IVC0032-8	164	0	39	0	0
IVC0032-9	82	0	49	0	0
IVC0032-12	137	0	49	0	0
IVC0032-20	72	0	20	0	0
IVC0014-1-1	20	0	6	0	0
IVC0002B-1-1	20	0	9	0	0
IVC0014-B-1-1	2	0	1	0	0
IVC0017-B-1-2	67	0	36	0	0
VM2164	27	0	38	0	0
IM5	260	0	247	0	0

[z]Date of adults released on seeds: Jan. 10 to 11, 1984; date of adult removed from seeds: Jan. 20, 1984; date of observation for emerging first-generation adults: Feb. 15, 1984.

Table 5. Performance of selected mungbean lines with some seeds undamaged by *C. chinensis*.[z]

Line No.	No. of Eggs Laid	No. of Seeds		Damaged (%)	No. of Emerging Adults
		damaged	undamaged		
IVC0021-7	14	2	3	40.0	2
IVC0023-5	205	96	13	88.1	96
IVC0023-9	60	4	29	12.1	4
IVC0023-10	209	135	16	89.4	127
IVC0023-12	186	181	13	93.3	161
IVC0023-17	123	36	98	26.9	36
IVC0023-20	163	140	25	84.8	150
IVC0026-1	128	4	43	8.5	4
IVC0026-2	118	4	66	5.7	4
IVC0026-5	68	26	19	57.8	26
IVC0032-6	127	7	41	14.6	7
IVC0008-B-1-1	8	1	3	25.0	1
IVC0014-B-1-2	4	1	2	33.3	1
IVC0014-B-3-3	80	1	115	0.9	1
IVC0014-B-3-8	112	2	85	2.3	2
IVC0014-B-3-9	60	5	31	13.9	5
IC1	125	28	251	10.0	28
IC3	171	93	159	36.9	129
MG2	195	64	323	16.5	66
VC1973A	181	171	83	67.3	171

[z]Date of adults released on seeds: Jan. 10-11, 1984; date of adult removed from seeds: Jan. 20, 1984; date of observation for emerging second-generation adults: Feb. 15, 1984.

100% seeds damaged. These seeds had at least one insect emergence hole, and all had a large number of bruchid adults.

Conclusion

The 40 entries (20 free of insects and 20 with some undamaged seeds) showed varying degrees of bruchid resistance. These entries will be planted in the field and, at flowering, will be backcrossed to high-yielding, disease-resistant, but bruchid-susceptible mungbean parents to obtain bruchid resistance in mungbean. One mungbean accession, V4997, which was free of first-generation adults will be evaluated further to confirm whether it is truly resistant to bruchid.

Mungbean Pathology

Screening for Resistance to Three Unknown POT-Y Virus Isolates and to CMV

Introduction

Several virus isolates have been recovered from mungbean. One isolate was identified as the mungbean strain of CMV. The other isolates (M2, M25, M4) are presently under investigation and have not yet been exactly characterized. They appear to be very similar in their host range, physical properties, particle morphology, and serological relationships. The results of some of these assays suggest that the isolates are related to blackeye cowpea mosaic virus (BlCMV) and adzukibean mosaic virus (AzMV).

Because of their wide host range which includes many commercially grown leguminous hosts and their seed transmission, incorporation of resistance into AVRDC's elite breeding lines should be very useful. This study was undertaken to determine if resistance is already found in AVRDC accessions.

Materials and Methods

Ten mungbean accessions (V1380, V1381, V1400, V1945, V1947, V2272, V2273, V2773, V2184, V3476) representing most of the parents of the elite breeding lines, and nine accessions (V1868, V2040, V2043, V2357, V2650, V2866, V2867, V4184, V4842) previously reported to be resistant to the mungbean strain of bean common mosaic virus (M-BCMV) were tested for their reaction to the unknown virus isolates M2, M4, and M25. In addition, 22 elite breeding lines (VC2768B, VC2764B, VC2764A, VC2763A, VC2755A, VC2750A, VC2778A, VC2778B, VC2768A, VC2720A, VC1973A, VC1560D, VC2719A, VC2572A, VC1628A, VC1482E, VC1647B, VC1168B, VC2307A, VC1000C, V3726, V3476) were screened for resistance to M25 and CMV. A total of 30 to 50 plants of each accession or line were inoculated at the primary leaf stage. Inocula were prepared by homogenizing fresh infected leaves of *P. vulgaris* cv. Bountiful (for M25, M2, M4) or *N. glutinosa* (for CMV) in 0.1M phosphate buffer at a ratio of 1:3 (w/v), with 0.1% thioglycollate added.

The plants were kept in flats outside the greenhouse and symptoms were recorded two weeks after inoculation. Plants without or with very mild symptoms were checked by ELISA. Ratings were done according to the following scheme: I = immune (no symptoms, no virus present); T = tolerant (symptomless); R = resistant (up to 5% of the plants infected); MR = moderately resistant (5-20% of the plants infected); MS = moderately susceptible (21-50% of the plants infected); S = susceptible (50% of the plants infected).

Results

All 10 accessions representing some common parentals of elite breeding lines were found to be susceptible to M2, M4, and M25, having more than 50% of the plants infected.

Two of the 22 elite breeding lines (VC2755A, VC1973A) were found to be immune to CMV and four (VC2764B, VC2764A, VC2768A, V3476) showed low CMV infection rates ranging from 2 to 13%. Both CMV immune lines and those with low infection rates had local lesions on the inoculated leaves, but were free of systemic infection.

All of the nine accessions reported to be resistant to M-BCMV were susceptible to each of the three unknown virus isolates, M2, M4, and M25. All lines reacted severely with mosaic and malformation to M2 and M25. Isolate M4, however, produced only mild mottle on these lines, indicating that this isolate may be different from the other two. From this we conclude that none of our unidentified mungbean virus isolates is M-BCMV. This finding is further supported by serological tests reported elsewhere.

Conclusion

The unidentified virus is not BCMV or a strain of it. Immunity to CMV but not to the unidentified virus is available in breeding lines. The source of resistance has not yet been identified.

Further Studies Towards the Identification of Three POTY Virus Isolates

Introduction

In 1983, a survey was conducted to find the "mungbean mottle virus" which had been used previously in our mungbean-virus resistance breeding program, but which had lost its infectivity. We also wanted to determine which other viruses occur on mungbean in Taiwan and to evaluate these for use in AVRDC's resistance breeding program. Several isolates recovered then were CMV. The other isolates could not be exactly identified on the basis of differential host reactions and serology.

Therefore, further hosts particularly those commonly used for the identification of common legume viruses, were tested. These included *P. vulgaris* cvs. Redlands Greenleaf C, Redlands Greenleaf B, Great Northern 123, Sanilac, Monroe, Jubila, Improved Tendergreen, Amanda for the differentiation of BCMV strains; *P. vulgaris* cvs. Black Turtle I and Black Turtle II; *Vigna sinensis* TUV 2480 and Blackeye, for the identification of blackeye cowpea mosaic virus (BICMV), cowpea aphid-borne mosaic virus (CAMV) and soybean mosaic virus (SMV). Some additional serological tests were also conducted.

Materials and Methods

For the determination of the host range, four to eight plants were inoculated with the use of 1:3 homogenate of fresh infected leaves in 0.1M phosphate buffer pH 7.2. Symptomless plants were checked by ELISA. The three mungbean isolates M2, M4, and M25 were tested in agar gel double diffusion test with antisera to adzukibean mosaic virus (AzMV), blackeye cowpea mosaic virus (BICMV), and the unknown soybean virus isolate PN. Antigens were prepared by homogenizing one part fresh leaves of virus-infected *N. benthamiana* with one part PBS containing 1.5% SDS. Antigens were added to the peripheral wells at a distance of 8.5 mm from the central well.

To determine seed transmission, seeds of mungbean and soybean cultivars previously artificially inoculated with isolate M25 were collected. Fifty seeds were sown and the emerging plants were assessed visually for symptom expression. Symptomless plants were checked by ELISA.

Results

The following hosts were systemically infected with all three virus isolates: *P. vulgaris* Bountiful, Pinto III, Saxa, Black Turtle 2 (Provvidenti), Dubbele Witte, Great Northern 123, Sanilac, Widusa, Michelite; *Vigna angularis* Jen Sen, Odate No. 1, *V. radiata* V1111, V2010 and 2773; and *Vigna unguiculata* Kaoshiung Green Pod, Early Ramshorn, Blackeye, Blue Goose. Local lesions were produced all three isolates on *P. vulgaris* Monroe.

The following hosts were immune to the three virus isolates: *Cassia occidentalis; G. max* Tainung No. 4, Davis; *P. vulgaris* Redlands Greenleaf C, Redlands Greenleaf B, Kentucky Wonder Waxpole, Kentucky Wonder Wax Runner Toperop; *Pisum sativum* Dark Skin Perfection; *Vicia faba; Cucumis sativus* Chicago Pickling; *Cucumis melo* Known You; *Datura stramonium* (R. Fulton strain); *Gomphrena globosa; Nicotiana glutinosa; Nicotiana tabacum* 'Samsun'; *Petunia hybrida* King Henry; *Tetragonia expansa; Vigna radiata* PI474118; and *Vigna unguiculata* TUV 2480.

The reactions of the other hosts are shown in Table 1.

None of the 13 soybean cultivars commercially grown in Taiwan (*G. max* TN3, TN15, KS9, Shih Shih, Mou Dou 205, Gun Tsuru, Talientou, AGS 147, Palmetto, Acc. No. G5, York, Ryokkoh, and Ryohyo) were susceptible to isolate M25. The other two isolates were not tested.

Two cowpea cultivars, Dagupan Pangasinan Collection No. 3.1 (Fengshan Tropical Horticulture Experiment Station (FTHES) Acc. No. LP27) and Dagupan Pangasinan Collection No. 4.3 (FTHES Acc. No. LP32) were immune to the virus.

All but two of seven yard-long beans tested (FTHES Acc. Nos. CP1, CP10, CP22, CP40, CP44, CP39, CP72) were susceptible to this virus isolate. The latter two could not be infected.

In ELISA tests, each of the three isolates reacted strongly with AzMV-AS. A positive reaction was also observed with BICMV-AS. A weak reaction was produced with antiserum to the unknown soybean isolate PN (PN-AS). No reaction was produced by the three isolates (Table 2) with BCMV monoclonal antibodies.

Table 1. Host reactions of three mungbean virus isolates, M2, M4, and M25.

Host Plant	M2	M4	M25
Glycine max			
Iwate-Wasekurome (Iizuka)	-/M	-/-	-/M
Bragg	-/M	-/-	-/-
Phaseolus vulgaris			
Black Turtle 1 (Provvidenti)	nLL/N,death	-/-	nLL/M,malf
Amanda	nLL/-	-/-	-/-
Immuna	-/Mo	-/-	-/Mo
Monroe	nLL/-	-/-	nLL/-
Jubila	nLL/-	-/-	-/-
Imp. Tendergreen	nLL/-	-/-	-/-
Vigna angularis			
Shiroazuki '100' (Iizuka)	nLL/-	-/-	nLL/-
Vigna unguiculata			
Yard-long bean local variety I (Green Pod)	-/Mo,RS	nLL/Mo	-/-

Table 2. ELISA reactions of the unknown mungbean isolates M2, M4, and M25.

Antigen	Antiserum				
	AzMV-AS	BICMV-AS	M4-AS	PN-AS	BCMV[z]
M2	++	+	+	+/-	-
M4	+	+	+	+/-	-
M25	++	+	+	+/-	-

[z]Monoclonal antibodies (test was conducted by G. Mink, Prosser, Washington, USA).

Isolate M25 was seed-transmitted in mungbean lines VC1168B and VC 2768B, by 12 and 10%, respectively.

The reactions on 10 of the 16 common bean cultivars (*P. vulgaris*) used by E. Drijfthout et al*. for the identification of BCMV and its strains indicated that our virus isolates were not BCMV as had been suggested earlier. This was supported by serological reactions using both nonstrain-specific and strain-specific BCMV monoclonal antibodies in ELISA.

From the reactions of our isolates on *P. vulgaris* Black Turtle I and Black Turtle II which have been proposed by Provvidenti** for the identification of BlCMV, it would appear that isolate M4 is indeed BlCMV. However, since all three isolates have previously shown to give a strong positive reaction with BlCMV-AS in ELISA tests and in ISEM, we believe that the other two isolates, M2 and M24, must be strains of the same virus that are very closely related to BlCMV, possibly adzukibean mosaic virus.

Conclusion

The host range of our unknown mungbean virus isolates appears to be restricted to leguminous crops. Besides mungbean, they commonly infect French bean, adzukibean, and cowpea. Soybean can also be infected experimentally, but does not appear to be a common natural host of this virus. In host range and serological reactions, isolates M2 and M25 closely resemble the unidentified soybean virus. However, there appears to be some host specialization. The unidentified soybean virus does not commonly infect mungbean, whereas soybean does not appear to be a common host of the unknown mungbean virus. On the basis of host range and serology, the mungbean isolates are not BCMV, but appear to be related to AzMV and BlCMV.

Greenhouse Seedling Screening for Resistance to Powdery Mildew

Introduction

Screening for resistance to mungbean powdery mildew (*Erysiphe polygoni*) has been conducted previously under natural infection. With this method, however, screening was not possible during the hot and humid seasons when the fungus is not generally a problem. Even in the cool and dry seasons, infection can be erratic and is often not homogenously distributed within the field. The present study was initiated to develop a method of screening seedlings in the greenhouse under a controlled environment and with artificial inoculation. The longevity of powdery mildew spores under extended periods of cold storage was also examined.

Materials and Methods

Greenhouse screening. A total of 117 entries were tested including 48 advanced lines, 64 lines and accessions previously reported at AVRDC as resistant, and five susceptible checks (Table 3). The plants were grown in plastic pots (two plants per pot, three pots per line) in the greenhouse and inoculated at the seedling stage by dusting them with spores from heavily infected leaves. Disease ratings were taken approximately 20 days after inoculation by visually assessing both the disease severity (percentage of leaf area affected) and the infection type.

The following classes were used for disease severity: 0, t (less than 5%), 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, and 100%.

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* Drijfthout, E., Silberuagel, M. J., and D. W. Burke. 1978. Differentiation of strains of bean common mosaic virus. Neth. J. Pl. Path. 84:13-26.

** Provvidenti, R. 1983. Two useful selections of the bean cultivar Black Turtle Soup for viral identification. Bean Improvement Cooperative 26:73-75.

The infection type was assessed as follows: I = immune; HR = highly resistant (a few small reddish necrotic spots without sporulation); R = resistant (necrotic spots with very little or no sporulation); MR = moderately resistant (some necrosis with little sporulation); MS = moderately susceptible (no necrosis, moderate sporulation); and S = susceptible (no necrosis, abundant sporulation).

Both severity and infection type were combined into an "infection coefficient" by assigning a coefficient to each infection type (I = 0; HR = 0.2; R = 0.4; MR = 0.6; MS = 0.8, and S = 1) and multiplying by the corresponding severity. The infection coefficient ranges from 0 (immunity) to 100 (extreme susceptibility).

Table 3. Reaction of mungbean breeding lines and accessions to powdery mildew (*Erysiphe polygoni*).

Advanced Breeding Lines (1984 advanced and elite yield trials)					
Line[z]	Infection Coefficient[y]		Line	Infection Coefficient	
VC 1000D (R)	2.5	5	VC 2770-B-15-1-B	8.5	12
1131B	6.0	12	2771A (R)	0.0	0
1178A	40.0	50	2777A	4.0	8
1502E (R)	0.0	0	2777-B-B(S)-3-B(R)	8.0	16
1560D (R)	0.5	1	2778C (R)	4.0	8
1647B	7.5	15	2789-B-2B(S)-4-B(R)	0.5	1
1973A	60.0	80	2802A (R)	0.5	1
2307A (R)	0.0	0	2804-9-B-2-B	2.0	4
2572A	40.0	50	2917-B-1-B-4-2B	55.0	70
2719A (R)	0.5	1	3000 3B-2-B	55.0	70
2720A (R)	2.5	5	3011-12-B-2-1-B	0.0	0
2742-16-B-1-B (R)	0.0	0	3011-12-B-2-2-B(R)	0.0	0
2746-3-2B-2-B (R)	3.0	6	3012A (R)	4.0	8
2754A (R)	45.0	60	3012-11-2B-1-B (R)	2.0	4
2755A	60.0	80	3027-6-2B-1-2B (R)	0.0	0
2762A (R)	30.0	40	3031A (R)	0.0	0
2762-1-2B-1-B (R)	0.5	1	3061A (R)	0.0	0
2762-B-67-B-1-B (R)	1.5	3	3108-2B-1-2B	1.5	3
2763A (R)	0.5	1	3112-B-1-1-2B	32.5	40
2764B (R)	3.0	6	3116-16-2B-2-B (R)	0.0	0
2764C	55.0	70	3116-26-2B-1-B	40.0	50
2764-11-2B-9-B	55.0	60	3117-7-2B-2-B (R)	17.5	20
2768A (R)	5.5	10	3199A (R)	0.0	0
2770B	10.5	16	3301-2B-1-1-2B (R)	16.0	20
Lines and Accessions Previously Reported as Resistant					
1. Lines					
VC 1000B	0.0	0	VC 3108-5-1-2-1-B	0.0	0
1000C	0.5	1	3179-3B-2-B	0.5	1
1209C	0.0	0	3199 3B-1-B	0.5	1
1482C	0.0	0	3303-B-1-2-1-2B	1.0	1
1482D	0.5	1	3340-B-1-2-1-2B	0.5	1
1560A	1.0	2	3471-2B-1-1-2B	0.5	1
1560D-7-2B-1-B	0.5	1	3492-2B-2-2-2B	1.0	2
2520A	1.5	3	3519-1-2-1-1	0.0	0
2528A	0.5	1	3519-1-3-2-2	0.5	1
2530A	32.5	40	3532-B-2-3-2	4.0	8
2707A	1.5	2	3543-B-1-2-1	0.5	1
2719B-18-B-3-B	0.5	1	3543-B-2-1-1	0.5	1
2750A	0.0	0	3580-B-2-2-2	0	0
3021-2-2B-1-B	0.0	0	3681-2-1-1-3	0	0

Table 3 (Continued)

Lines and Accessions Previously Reported as Resistant

Accessions	Infection Coefficient		Accessions	Infection Coefficient	
2. Accessions					
V 1104	4.0	8	V 3912	0.0	0
1533	4.0	6	4186	0.0	0
1548	0.0	0	4189	0.0	0
1593	0.5	1	4207	1.5	3
1741	0.0	0	4281	0.0	0
2013	11.5	18	4574	0.0	0
2106			4584	0.0	0
2159	8.0	16	4631	0.0	0
2272	1.5	2	4658	0.0	0
2386	1.0	2	4662	0.5	1
2407	0.0	0	4668	0.0	0
2416	0.5	1	4717	0.0	0
2417	0.5	1	4718	3.0	5
2673	1.5	3	4799	0.0	0
2675	0.0	0	4883	0.5	1
2676	0.5	1	4966	3.0	5
2773	2.0	3	4967	0.5	1
3182	6.5	12	4990	0.0	0

Susceptible Checks

Line/Accession	Infection Coefficient		Line/Accession	Infection Coefficient	
V 1944	60	80	V 3726	50	70
1945	50	70	VC 1628A	25	30
3476	60	80			

[z]Advanced breeding lines reported as resistant are marked (R). [y]The 1st column is the average infection coefficient (over three replicates), the 2nd column is the highest coefficient.

Longevity of spores in cold storage. The spores were sucked from infected plants in the greenhouse with a small aspirator (microcyclone type) coupled to a vacuum water pump. They were stored at 5°C in gelatin capsules. Half of the capsules were stored in a desiccator containing $CaCl_2$ crystals. Infectivity was determined visually at monthly intervals by dusting part of the spore material over detached healthy mungbean leaves whose petioles were immersed in water. To determine viability, a small bit of spore powder was dusted on a glass slide kept in a moist petri dish. Spore germination was checked under the microscope after 24 hr.

Results

Greenhouse screening. The results are summarized in Table 3. The present data generally confirm previous results. Some differences were found, however. Advanced breeding lines VC 3011-12-B-2-1-B, 3108-2B-1-2B, 2804-9-B-2-B, and 2777A were not reported resistant, but turned out to be highly resistant in the present study. Lines VC 2754A and 2762A which were reported resistant, were found susceptible in this screening.

For the rest of the accessions and lines previously reported resistant, the present results agreed closely. Almost all the entries were found highly resistant. A total of 29 accessions (out of 36) and 26 lines (out of 28) were immune or nearly immune to powdery mildew. The only serious discrepancy was found in line VC2530A which was moderately susceptible in this study.

The results of the greenhouse screening technique with artificial inoculation were found very similar to those of previous field screenings that have used natural infection. Seedling

screening in the greenhouse had the following advantages: it saved both time and space, allowed a more accurate disease scoring, and could be done year round.

Longevity of powdery mildew spores in cold storage. The spore material stored in the cold room-both in or outside the desiccator-was found infectious after at least six months in storage (the study is still ongoing). Spore viability-as measured by percentage of germination-decreased, but was still high after a six-month storage (Table 4). Storage in the desiccator did not have any appreciable effect on spore germination.

The high longevity of powdery mildew spores in cold storage is another advantage of the greenhouse screening technique as, in periods of interrupted screening, inoculum can be stored in the cold room for several months and used whenever needed to start new infections.

Conclusion

More use should be made of the greenhouse screening technique in the AVRDC mungbean improvement program in view of the advantages it has over conventional field screening using natural infection.

Table 4. Viability of mungbean powdery mildew spores after different periods of cold storage.

Storage Condition	Germination (%)					
	months in storage					
	1	2	3	4	5	6
5°C, desiccator	90	86	79	75	76	72
5°C, no desiccator	88	89	75	70	72	65

Soybean Breeding

Germplasm Collection

Introduction

Germplasm provides the necessary genetic variability for the plant breeding program. It is estimated that roughly 30% of the world soybean germplasm resources is yet to be collected, documented, and utilized. Therefore, AVRDC will continue to collect and obtain germplasm from all possible sources.

Materials and Methods

Through communication with potential agencies who have new germplasm collections, attempts were made to obtain them. The International Board for Plant Genetic Resources (IBPGR) organized a legume-germplasm collection trip to Laos, and AVRDC, in cooperation with Japanese, Thai, and Laotian scientists, collected soybeans, in addition to other legumes. The FAO/IBPGR joint soybean-germplasm collection missions in Vietnam and Zambia shared the collected materials with AVRDC.

Results

From nine countries, 1,807 accessions were received bringing the total collection to 12,330 (Table 1). Notable among the new accessions are the yellow-seeded mutant from the black-

Table 1. Soybean germplasm collection at AVRDC, 1984.[z]

Source Country	No. of Entries[y] total	subtotal	Remarks
Australia	1	1	
India	4	4	Mutants from Kalitur
Indonesia	127	1	Gigas mutant
		126	
Japan	1	1	
Laos	26	26	
South Africa	66	66	
U.S.A.	1,556	1	White fly resistant(?)
		1	Contains gene Ix_1Ix_1
		4	Resistant to defoliators(?)
		8	High protein
		1	Contains gene Ix_3Ix_3
		1,541	
Vietnam	22	22	
Zambia	4	4	
Total		1,807	

[z]Total at the end of 1983: 10,523; total at the end of 1984: 12,330. [y]Most of the entries are still under observation; therefore, accession numbers have not been assigned to the new entries.

seeded popular cultivar Kalitur from India and a gigas mutant from Indonesia. Two accessions from the U.S.A. which lack lipoxygenase 1 and 3 are also noteworthy if they are devoid of beany flavor.

Conclusion

Valuable additional germplasm has been added to the collection. Documentation of these accessions will help disclose genes useful for our breeding program.

Evaluation of Germplasm

Introduction

Evaluation of germplasm will reveal genotypes which are valuable for the breeding program to accomplish the defined objectives.

Materials and Methods

As part of an IBPGR documentation project of soybean germplasm, 2,898 AVRDC accessions were evaluated. Planting was made on February 20 and 21 and again on August 26, 1984. Each entry was planted on two, one-meter-long rows on a raised bed with plants spaced 50 cm between rows and 10 cm between hills. Two seedlings were planted per hill. Observations were made on 25 characters following the IBPGR Soybean Descriptor list. The processing of the data is yet to be completed, but the preliminary results are here presented.

Results

Since the plot size is small the absolute yield should be viewed with caution. Therefore, the yield data should be taken as a relative measure for choosing potential genotypes to be evaluated in more detail in large plots. The 10 highest yielding entries and their selected attributes are given in Table 2. Accessions which matured in 79 to 85 days and had a yield potential of more than 3 t/ha are given in Table 3.

Among the 2,898 accessions evaluated, 26 had a combination of gray pubescence, large seed size, more number of pods per plant, and the characteristics similar to G9053, a vegetable soybean (Table 4). They were selected for further evaluation.

Table 2. Ten selected high-yielding accessions of the soybean-germplasm observation trial at AVRDC.[z]

Acc. No.	PI No. or Name	Original Source	Yield (t/ha)	No. of Plants at Harvest	DM[y]	100-Seed Wt (g)
G9642	UPL-SY2	Philippines	7.4	49	111	18
G10383	ZFA3227	Zambia	6.9	42	116	15
G10253	Hwalien Selection No. 4	Taiwan	6.7	41	116	24
G5084	Kohane Daizu	Japan	6.3	40	120	11
G10156	Sable	Zimbabwe	6.2	30	121	17
G9700	KLV26	Korea	6.2	47	114	15
G9828	KLV161	Korea	6.1	38	110	29
G2854	Kinai-Kurosengoku	Japan	6.1	33	104	15
G2509	Davis	Columbia	6.0	31	104	18
G3725	Var. Card No. 214 Pelican I-20-0, 69-133	Australia	5.8	29	115	15

[z]Planted in February 1984. [y]Days to maturity.

In the August 26, 1984 planting, G10178 (CI-1 from Kaohsiung DAIS) and G10348 (Ohsode early from Japan) were found to be almost free from soybean rust, which finding needs to be confirmed.

Conclusion

A preliminary selection from the germplasm collection has been made on the basis of early maturity, high yield potential, and suitability as vegetable soybean. They will be evaluated in more detail.

Table 3. Eight selected early-maturing and high-yielding accessions.[z]

Acc. No.	PI No. or Name	Original Source	Yield (t/ha)	No. of Plants at Harvest	DM[y]	100-Seed Wt (g)
G9784	KLV116	Korea	3.1	36	79	21
G3699	Var Card No. 180, 69-370 Ling-Pu-Ta-Tou	Australia	3.2	38	81	11
G5106-B	Unknown	Japan	4.6	33	83	24
G2865	Jin-nai	Japan	3.2	42	85	12
G2794	Wase-daizu 11	Japan	3.6	54	85	16
G10163	SS77054	Korea	4.1	50	85	20
G2930	Higomusume	Japan	3.2	56	85	17
G2744	Suzumame	Japan	3.3	48	85	14

[z]Selected from 2,898 accessions planted in February, 1984 at AVRDC. [y]Days to maturity.

Table 4. Twenty-six accessions selected as suitable vegetable soybeans.[z]

Acc. No.	PI No. or Name	Original Source	100-Seed Wt (g)	Yield (t/ha)	DM[y]	Pod
G10490	Kinshu	Japan	45	3.0	98	18
G10168	Yukirname	Taiwan	45	3.5	100	16
G3231	KLS303-2	Korea	42	2.7	98	13
G10161	Banseykokok	Korea	41	2.5	95	16
G3227	KLS301-2	Korea	40	2.8	98	13
G10489	Hokai Shirogewase	Japan	38	2.9	98	15
G10522	Wase Hakucho	Japan	38	2.4	94	14
G10479	Tamasudare	Japan	37	2.5	101	15
G9373	KaeriGnt 131-8	Korea	37	2.8	94	16
G10502	Fukumusume	Japan	37	2.1	95	11
G10134	Ryokkoh[x]	Taiwan	36	1.2	106	13
G10514	Shirojishi	Japan	36	2.5	97	12
G9972	Hakucho 3	Japan	36	2.7	95	15
G9821	KLV154	Korea	36	4.7	98	17
G10505	Shiranui Ichigo #1	Japan	35	2.5	98	15
G3181	KLS131-1	Korea	35	2.5	100	19
G10515	Suzumo Hakucho	Japan	34	2.9	88	13
G9970	Fulbasket	Japan	34	2.9	92	14
G10486	Sagimidori	Japan	33	2.6	94	13
G10487	Green Homer	Japan	33	2.8	90	14
G1999	Ou-yuan Early 1	Taiwan	33	1.3	95	16
G3168	KLS122	Korea	33	2.1	101	22
G2047-A	Early Oku-hala	Taiwan	32	3.5	95	14
G2186	Chodaedu	Korea	31	2.1	84	27
G4861	Tousan 65	Japan	31	3.3	101	22
G9948	Zen Wu #2[x]	Taiwan	30	2.0	106	15

[z]Selected from 2,898 accessions planted in February 1984 at AVRDC. [y]Days to maturity. [x]Vegetable soybeans in Taiwan.

Hybridization Program

Introduction

Hybridization is done to add desirable characters to a superior cultivar or a selection which lacks them. Through hybridization new combinations and recombinations of genes are expected which can be selected in succeeding generations, provided appropriate selection methods are employed.

Materials and Methods

Thirty-one accessions with desirable characters, such as resistance or tolerance to diseases and insects were crossed with 33 promising AVRDC *Glycine* selections (AGS) to make further improvements. The crosses were mostly made on plants grown in the greenhouse from March to October.

Results

To combine resistance or tolerance to rust, soybean mosaic virus, bacterial pustule, downy mildew, beanfly, and defoliating insects, 146 crosses were made. In order to improve the yield potential of vegetable soybeans, 19 crosses were made. Nineteen other crosses were made to accomplish additional objectives (Table 5).

Conclusion

In the succeeding generations, by applying a suitable selection technique and pressure, improved selections with the necessary disease and/or insect resistance or tolerance combined with high yield and wide adaptability may be expected from the new hybridizations.

Table 5. No. of crosses made in 1984 at AVRDC.

Objectives	No. of Crosses
Resistance/tolerance to rust	60
Backcross for resistance to SMV	54
Backcross for resistance to beanfly	14
Improvement of vegetable soybean	19
Backcross for narrow leaf	3
Incorporation of genes with less lipoxygenase	10
Resistance to bacterial pustule (BP)	9
Resistance to BP and downy mildew (DM)	5
Incorporation of photoperiod insensitivity	2
Inheritance of G9053 podding type	4
Resistance to defoliating insects	4
Total	184

Breeding for Photoperiod Insensitivity

Introduction

The object was to identify photoperiod-insensitive selections first and evaluate them for yield potential in later generations. F1 plants from 30 crosses which had at least one photoperiod-insensitive parent were planted in February 1983. The selected photoperiod-insensitive F2 plants were planted in September 1983.

Materials and Methods

Seeds from selected F3 plants were planted on March 26, 1984. F2, F3, and F4 plants were grown with artificial light to extend the natural photoperiod to 14 hr. The light intensity at plant canopy was about 58 to 64 $\mu Em^{-2}S^{-1}$ PAR. Seeds from each plant were planted in a 3 × 0.5 m plot. Observations were made on days to flowering and days to maturity.

Majority of the entries which neither flowered nor matured were discarded in the F2, F3, and F4 generations. Those that did were harvested to further advance the generation and evaluate their photo-periodic response in the September season.

Results

A sample of entries selected from the F4 generation is presented, along with the photoperiod-insensitive check G215. in Table 6. Photoperiod-sensitive check G2120 did not flower even by the time the F4 plants matured. Out of 233 lines evaluated, only three did not mature.

Conclusion

In the September season, homozygous photoperiod-insensitive selections will be identified in the F5 generation which will be evaluated for yield in replicated trials in the February, July, and September seasons of 1985. The yield potential of these selections will be compared with their parents.

Table 6. Selections from the screening of the F4 generation for insensitivity to photoperiod under 14 hr.[z]

Pedigree Designation	Pedigree	Days to Flowering (DF)	Days to Maturity (DM)	DM-DF
GC82105-7-6-6	Pine Dell Perfection × (SRF400 × PI297550)	37	90	53
GC82137-10-12-12	PI153240 × Takii's Extra Early	34	86	52
GC82137-10-13-9	"	33	85	52
GC82137-11-10-9	"	34	87	53
GC82137-11-12-6	"	45	89	44
GC82137-10-13-6	"	30	83	53
GC82137-10-13-10	"	32	85	53
GC82137-10-15-8	"	34	87	53
GC82137-11-12-8	"	32	86	54
G215 (Ck)		34	89	55

[z]Total number of selections evaluated: 233.

Yield Potential of Photoperiod-Insensitive Accessions

Introduction

Although photoperiod-insensitive accessions were identified in the germplasm, their yield potential was not fully investigated. From literature it was assumed that they were generally poor yielders, therefore, they were utilized in the breeding program. The objective of this experiment was to determine the variability in yield potential of the photoperiod-insensitive accessions in different seasons.

Materials and Methods

On February 24 and July 14 a total of 101 accessions and five checks (G2120, AGS62, AGS129, AGS130, and AGS154) were planted. A randomized complete block design with two replications was used. Plot size was 2 x 1 m. Each entry was planted in two rows 50 cm apart and 10 cm between hills with two plants per hill. Observations were made on major agronomic characteristics.

Results

The mean days to maturity in the February and July plantings were 98 and 81 days, respectively (Fig. 1). From the distribution of the entries in different maturity categories, it was obvious that either temperature or photoperiod and temperature influenced the maturity duration of the photoperiod-insensitive accessions. Similar variability for yield was also observed between February and July seasons. The mean yield in February was higher than that of July (Fig. 2).

In the February planting, G386 gave 3.9 t/ha in 106 days compared to AGS129's yield of 3.6 t/ha in 111 days. However, in the July planting photoperiod-sensitive G2120 gave 4 t/ha in 106 days compared to 3.5 t/ha in 87 days by AGS129.

Photoperiod-insensitive accessions with high yield potential combined with early maturity in one or two seasons are given in Table 7. G782 and G180 appeared to be the best performer. The results also suggest that AGS62, AGS129, and AGS130 have fairly stable high yield although the days to maturity vary with season.

Conclusion

Upon obtaining the results from the September season all the three data will be analyzed, and high-yielding photoperiod-insensitive accessions will be selected for further multilocational, multienviron-mental evaluation through AVRDC Soybean Evaluation Trial (ASET), if found suitable. Otherwise, they will be used in breeding for further improvements.

Preliminary and Intermediate Yield Trials

Introduction

Promising breeding lines undergo preliminary (PYTs) and then intermediate (IYTs) yield trials. Both PYTs and IYTs are conducted in the February, July, and September seasons of the same year. Lines selected from IYTs are included in advanced yield trials (AYT).

Materials and Methods

The PYTs were conducted in three groups and the IYTs, in two groups. The details on experimental design and dates of planting are given in Table 8. For the February-planted PYTs and IYTs, a split plot design was used. The main plot was maintained with and without fungicide protection, and the subplots were genotypes. Plot sizes for the PYTs and IYTs were 3 x 1 m and 3 × 2 m, respectively. The PYTs had two rows per plot while the IYTs had four rows; both trials had two replicates.

For the fungicide treatment, Dithane M-45 was sprayed from April 10 to 24, 1984 when the first rust symptoms were observed in PYT and IYT. Thereafter, three more sprays were given on April 24 (PYT alone), May 3, and May 10, 1984 for both trials. Data for all the agronomic characters were collected and analyzed. Selections were based on yield, minimum yield reduction due to rust, days to maturity, and adaptability to more than one season. Since there was no serious rust in the July planting season, a regular lattice design was used.

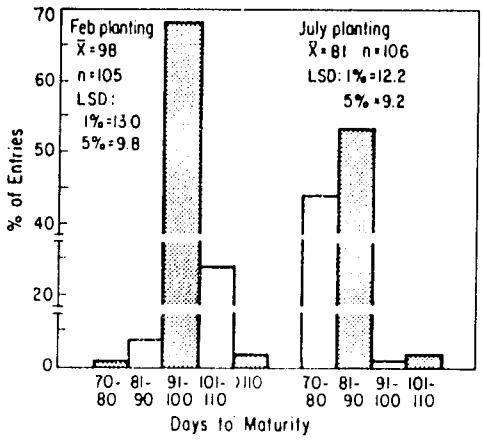


Fig. 1. Frequency distribution of photoperiod-insensitive accessions for days to maturity.

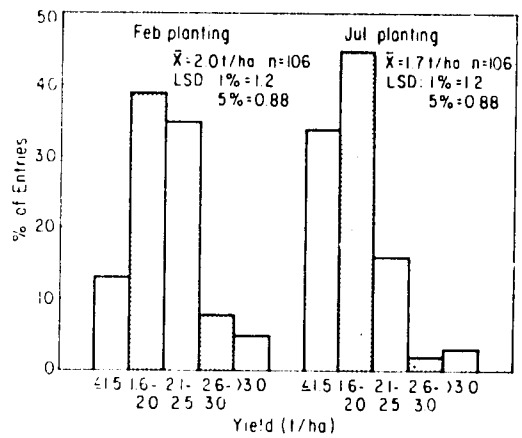


Fig. 2. Frequency distribution of photoperiod-insensitive accessions for yield.

Table 7. Selections from photoperiod-insensitive accessions for high yield and early maturity in one or two seasons.

Acc. No.	PI No./Name/ Pedigree	Yield (t/ha)		Days to Flowering		Days to Maturity	
		Feb.	July	Feb.	July	Feb.	July
G782	81035	3.5	3.0	47	34	97	75
G1034	68466 486	2.7	1.8	38	30	98	88
G161[z]	153297	2.6	2.0	43	32	96	82
G230	238920	2.5	1.9	47	38	91	83
G788	82263-3 828	2.5	1.4	37	31	98	90
G190	189869	2.5	2.0	34	28	98	83
G1032	68446 478	2.5	1.8	34	30	95	88
G480	92565	2.4	2.2	38	28	97	79
G180	180516	2.4	2.3	46	32	90	73
G216	194648	1.8	2.4	46	29	98	75
G965	189959	2.1	2.3	39	30	96	75
G277	153305	1.5	2.2	43	30	100	77
G181	180517	2.1	2.1	51	32	94	76
G2120 (Ck_1)	86736	–[y]	4.0	–	63	–	106
AGS62 (Ck_2)	SRF400 x PI297550	2.4	2.3	38	32	106	86
AGS129 (Ck_3)	Shih Shih x SRF400	3.7	3.5	49	37	111	87
AGS130 (Ck_4)	TN #4 x Yagi 1	2.7	2.7	55	43	109	90
AGS154 (Ck_5)	AGS2 x PI194647	2.8	1.8	47	35	109	87
LSD (.05)		0.87	0.88	7	5	10	9

[z]Highly resistant to bacterial pustule and downy mildew. [y]G2120 did not mature when the trial was terminated.

Table 8. Date of planting and experimental design of PYTs and IYTs in 1984.[z]

Experiment	Design		Date of Planting	
	spring	summer	spring	summer
PYT I	split-plot	10 x 10 double lattice	Feb. 8	July 27
PYT II	split-plot	12 x 12 double lattice	Feb. 8	July 27
PYT III	split-plot	9 x 10 rectangular lattice	Feb. 9	July 26
IYT I	split-plot	7 x 8 rectangular lattice	Feb. 8	July 13
IYT II	split-plot	7 x 7 double lattice	Feb. 7	July 13

[z]PYT = preliminary yield trials, IYT = intermediate yield trials.

Results

February planting. In all the PYTs, there were no significant differences between the fungicide and nonfungicide treatments and between fungicide and genotype However, there were significant differences between genotypes (Table 9). In PYT I and II none of the entries were significantly higher yielding than the check Shih Shih; but in PYT III, 11 entries from four crosses significantly outyielded it by 30 to 53% (Table 10).

Table 9. Analysis of variance of PYTs in the February planting, 1984 AVRDC.

Source	Trials[z]								
	PYT 1			PYT 2			PYT 3		
	DF	MS	F-value	DF	MS	F-value	DF	MS	F-value
Fungicide (F)	1	6784436.1	1.4 NS	1	14691787.1	5.73 NS	1	29080368.4	3.85 NS
Rep 1	1	479560.3	0.1 NS	1	236.7	0.0 NS	1	2706835.7	0.36 NS
Error (a)	1	4856144		1	25562217.8		1	7547979.3	
Genotype (G)	96	2804209.9	8.6**	143	990397.4	4.19**	89	879807.4	2.38**
F×G	96	169811.2	0.52 NS	143	225675.6	0.96 NS	89	261881.8	0.71 NS
Error (b)	192	328161.4		286	236255.0		178	369515.1	
CV (%)			19.0			14.0			18.0
Mean yield			3.0 t/ha			3.5 t/ha			3.3 t/ha

[z]MS = mean square; ** = significant at the 0.0/level; NS = not significant.

Table 10. Mean yield of high-yielding genotypes in PYT III in the February planting.[z]

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)
GC60002-2-10-8	4.6	110	20
GC60014-7-30-8	4.4	115	18
GC60035-1-15-8	4.2	115	20
GC60011-4-8-6	4.2	114	18
GC60035-1-15-6	4.2	114	20
GC60035-1-15-11	4.2	116	20
GC60035-1-15-10	4.1	115	20
GC60002-2-10-10	4.1	110	18
GC60011-4-8-9	4.0	114	15
GC60011-1-18-6	4.0	115	20
GC60014-10-1-22-9	3.9	114	11
G38 (Shih Shih) (Ck)	3.0	107	21
G42 (Ck)	1.6	109	20
Mean of 90 entries	3.3	114	18
CV (%)	18	2	6
LSD (.05)	0.85	3	2

[z]PYT = preliminary yield trial

Although the first rust symptom appeared just prior to R_1, the development and progress of the epidemic was not severe enough to affect the yields. A mild disease infection and some level of tolerance in most of the genotypes resulted in insignificant differences between the fungicide and nonfungicide treatments. However, since there was a large number of genotypes using the fungicide as the main plot, the experimen-tal design was not sensitive enough to identify the differences.

Similar to PYTs, in IYT I and II the differences between fungicide and nonfungicide treatment (main plot) and the interaction between the main plot and the subplot (genotypes) were insignificant. The mean yield of genotypes with fungicide in IYT I was 2.8 t/ha and without fungicide, 2.2 t/ha. In IYT II the mean yields with and without fungicide were 2.6

and 1.7 t/ha, respectively. Four entries had 25 to 33% significantly higher yields than the checks Shih Shih, AGS181, and AGS182 (Table 11). In IYT II only GC60038-3-7-12-10-7 with 3.1 t/ha significantly outyielded the high-yielding check AGS181.

In the majority of the trials in the February planting, late maturity was significantly correlated with high yield (r = 0.44** to 0.56**). Since there was highly significant correlation between yield and the treatment with and without fungicide in all the PYTs and IYTs (r = 0.65** to 0.89**), it appears that we can make high-yielding selections either with or without fungicide and expect to have tolerance to soybean rust.

July planting. In the July planting 16 selections from PTY I, 31 from PYT II, and 33 from PYT III significantly outyielded the checks Shih Shih or G42. The yield ranges in PYT I, II, and III were 0.5 to 3.1 t/ha, 1.3 to 3.0 t/ha, 1.2 to 2.6 t/ha, respectively. A few selected high-yielding entries from each of the PYTs are given in Tables 12, 13, and 14.

Among the IYTs planted in July, AGS66 was the highest yielder in IYT-I in 87 days (Table 15). AGS129 was on par with AGS66 on yield in 89 days. Six entries had yields higher than AGS182 and G2261.

In IYT-II, GC60068-9-11 was the highest yielder on par with AGS129 (Table 16). Four entries had higher yield than the check AGS182.

Conclusion

A number of promising selections have been made in PYTs and IYTs for either IYT or AYT, respectively.

Table 11. High-yielding selections from IYT I in the February planting.[z]

Cross Designation	Yield (t/ha)	Days to Maturity	100-Seed Wt (g)
GC60066-237B-7-10-6-7	3.2	111	16
GC50261-1-21-6-1	3.0	110	15
GC50106-11-79-9-6-6-8	3.0	112	13
GC50227-5-27-6-13	3.0	112	18
G38 (Shih Shih) (Ck)	2.4	102	19
AGS181 (Ck)	2.4	99	18
AGS182 (Ck)	2.3	97	18
Mean of 53 entries	2.5	110	7
CV (%)	14	2	3
LSD (.05)	0.49	4	2

[z]IYT = intermediate yield trial.

Table 12. High-yielding entries selected from PYT I in the July planting, 1984.[z]

Cross No.	Pedigree Designation	Yield (t/ha)	DM[y]	100-Seed Wt (g)	Remarks
GC60045-3-6-7-7-54	Shih Shih × Clark 63	3.1	80	14	BP[x]
G10223	P27	2.9	85	11	BP
G10146	SJ239	2.7	100	10	BP
GC60045-3-6-7-7-72	Shih Shih × Clark 63	2.6	80	14	BP
G10154	Hwei Tao Hwang	2.6	73	14	
G10296	PI131702G	2.5	83	13	BP
G38 (Ck)	Shih Shih	2.0	72	13	
G42 (Ck)	Mikawashima	1.3	76	19	
Mean		0.2	81	12	
CV (%)		9	6	5	
LSD (.05)		0.37	9	1	

[z]PYT = preliminary yield trial. [y]Days to maturity. [x]Field resistant to bacterial pustule.

Table 13. High-yielding entries selected from PYT II in the July planting, 1984.[z]

Cross No.	Pedigree Designation	Yield (t/ha)	DM[y]	100-Seed Wt (g)	Remarks
GC60087-7-6-10-8E-71	Shinsei x PI248407	3.0	84	17	BP[x]
GC60087-7-6-10-8E-65	"	2.8	84	14	BP
GC60038-3-7-12-10-7-81	UPSL-85 x TN #4	2.8	83	12	BP
GC60087-7-6-8-7E-22	Shinsei x PI248407	2.7	81	17	BP
GC60049-5-6-6-12-7-55	PI194647 x Clark 63	2.7	76	13	BP
GC60038-3-7-12-10-7-34	UPSL-85 x TN #4	2.7	84	12	BP
GC60058-12-6-6-1-13	PI248407 x AGS #2	2.7	79	11	BP
G42 (Ck)	Mikawashima	2.1	70	20	
G38 (Ck)	Shih Shih	1.9	75	11	
Mean		2.2	83	12	
CV (%)		8	2	6	
LSD (.05)		0.32	2.4	2	

[z]PYT = preliminary yield trial. [y]Days to maturity. [x]Field resistant to bacterial pustule.

Table 14. High-yielding entries selected from PYT III in the July planting, 1984.[z]

Cross No.	Pedigree Designation	Yield (t/ha)	DM[y]	100-Seed Wt (g)	Remarks
GC60011-1-32-11	Clark 63 x TN #4	2.5	87	12	
GC60058-15-1-20-11	PI248407 x AGS #2	2.5	86	8	BP[x]
GC60011-4-41-11	Clark 63 x TN #4	2.4	88	14	
GC60011-4-17-9	"	2.4	87	15	BP
GC60011-1-18-10	"	2.4	87	13	
G38 (Ck)	Shih Shih	1.8	75	12	
G42 (Ck)	Mikawashima	1.6	72	21	
Mean		2.0	86	13	
CV (%)		8	1	4	
LSD (.05)		0.32	2	1	

[z]PYT = preliminary yield trial. [y]Days to maturity. [x]Field resistant to bacterial pustule.

Table 15. High-yielding selections from IYT I in the July planting, 1984.[z]

Cross No.	Pedigree Designation	Yield (t/ha)	DM[y]	100-Seed Wt (g)
GC50261-1-21-6-1	KS739 x Akiyoshi	3.2	86	12
GC60066-107A-20-15-6-9	PI317334A x AGS #2	3.1	93	11
K98-9		2.9	89	15
GC60087-7-6-9-8E	Shinsei x PI248407	2.9	90	17
GC60066-237B-7-10-6-7	PI317334A x AGS #2	2.9	90	11
GC60087-7-6-10-7E	Shinsei x PI248407	2.9	91	17
AGS66 (Ck)	Forrest x Shih Shih	3.3	87	11
AGS129 (Ck)	Shih Shih x SRF400	3.0	89	13
AGS181	Shih Shih x PI230971	2.6	81	15
G2263	TN15	2.4	81	14
G38	Shih Shih	2.4	81	14
AGS182	Shih Shih x PI230971	2.3	81	14
G10381	KS8	2.1	95	16
Mean		2.5	89	13
CV (%)		6	2	4
LSD (.05)		0.32	4	1

[z]IYT = intermediate yield trial. [y]Days to maturity.

Table 16. High-yielding selections from IYT-II in the July planting, 1984.[z]

Cross No.	Pedigree Designation	Yield (t/ha)	DM[y]	100-Seed Wt (g)
GC60068-9-11	PI317334B x AGS #2	3.4	90	12
GC60068-9-9	"	3.0	94	10
GC60068-9-6	"	3.0	97	11
GC50299-7-6-6	Jaerae #12 x TN #4	2.9	89	12
AGS129 (Ck)	Shih Shih x SRF400	3.1	94	13
AGS182 (Ck)	Shih Shih x PI230971	2.3	87	14
G2261 (Ck)	TN15	2.2	83	15
AGS181 (Ck)	Shih Shih x PI230971	2.2	84	15
G38 (Ck)	Shih Shih	1.7	86	13
G42 (Ck)	Mikawashima	1.2	83	23
Mean		2.3	93	13
CV (%)		9	3	4
LSD (.05)		0.42	5	1

[z]IYT = intermediate yield trial. [y]Days to maturity.

Preliminary Yield Trial for Vegetable Soybean

Introduction

Vegetable soybeans can be grown even during the rainy season when other vegetables are in short supply. They can also serve as an export and cash crop providing employment opportunities in rural areas. From Taiwan $30 million worth of vegetable soybeans are exported annually to Japan. New accessions from observational trials have been included in a preliminary yield trial this year.

Materials and Methods

Fifty-six accessions were planted on February 10, 1984. Tzurunoku and Ryokkoh were included as checks. Plot size was 3 x 2 m and each plot had four rows. The plants in the middle two rows were harvested for yield evaluation. Those in the remaining two end rows were harvested to save the seeds. A 7 x 8 lattice design with two replica-tions was used. Observations were made on pod length, pubescence color, number of pods per kilogram, percentage of two or more seeded pods, and yield. Selections will be based on all the above parameters.

Results

Four accessions significantly outyielded the check G9053 for pod weight by 19 to 31% (Table 17). Three accessions outyielded the check for whole plant weight. All the selected accessions except G4035, had more than 50 g green seed weight. The high yielders had a high percentage of (90% or more) two-or three-seeded pods. However, pod size was small in many of them resulting in more pods per kilogram than are required for the frozen soybean market which needs 350 or less pods per kilogram. Compared to the check cultivars, four selected entries were late maturing.

Conclusion

Six new accessions have been selected for inclusion in the new AVRDC vegetable soybean evaluation trial (AVSET). Results from the July planting will be compared in making the final selection for the 1986 AVSET.

Table 17. Selections with high yield potential and good vegetable soybean characteristics.

AVRDC Acc. No.	Yield (t/ha) pod wt	Yield (t/ha) whole plant wt	100-Seed Wt (g)	Two or More Seeded Pods (%)	No. of Pods/kg	DM[z]
G4035	13.5	31.3	39	90	662	102
G2246	13.3	24.8	51	90	446	96
G10139	12.7	29.4	62	93	398	102
G6852	12.3	23.5	81	83	305	96
G10504	10.7	21.3	86	67	263	88
G10522	10.8	20.8	63	86	418	80
G9053 (Ck)	10.3	22.2	62	81	425	88
G10134 (Ck)	11.5	25.1	88	71	283	88
Mean of 56 Entries	9.1	18.7	58	82	–	84
LSD (.05)	0.97	1.5	9	–	–	4

[z]Days to maturity.

Mutation Breeding

Introduction

A mutant following irradiation of AGS2 was less sensitive to photo-period than AGS2. Following the preliminary yield trial (PYT), selected entries have been included in an intermediate yield trial (IYT).

Materials and Methods

In order to evaluate the selections for soybean rust in the February planting, a split plot design was used. The treatment with and without fungicide served as the main plot while the genotypes were the subplots. In the July planting a lattice design was used. The details of the experiment are given in Table 18. Observations were made on the major agronomic characters. Protein and oil contents were also determined. An early maturing accession, G42, and the late maturing parent of the mutant, AGS2, were used as checks for comparison.

Results

Unlike the other PYTs and IYTs, in the February planting, significant yield differences (at the 5% level) were observed between the treatments with and without fungicide (Table 19). The mean yield with fungicide was 3.1 t/ha, while without fungicide it was 2.5 t/ha. Even after 117 days when all the mutants were harvested G2120 was still in the R_5 stage and could not be harvested. All the mutants significantly outyielded the check G42.

The correlation between yield with spray and without spray was highly significant [r = 0.60** (Fig. 3)]. There were significant differences in yield between fungicide treatments in 19 genotypes, including the check G42. In spite of high rust-infection levels in some of the mutant lines the yield potential was high (Table 20). The late-maturing genotypes yielded higher (r = 0.814**), and as the seed size decreased the yield increased (r = 0.78**). It was also interesting that small seed size was associated with late maturity (r = 0.93**).

Table 18. Details of the IYT with selected AGS2 early mutant.[z]

Date Planted	Date Harvested	Expt. Design	Plot Size	Harvested Area	No. of Entries	Replicates
Feb. 8	June 5	split-plot	3m x 2m	$6m^2$	36	2
July 14	Oct. 13	6 x 6 lattice	3m x 2m	$6m^2$	36	2

[z]IYT = intermediate yield trial.

Table 19. Analysis of variance of the IYT of AGS2 early mutant selections.[z]

Source	Degree of Freedom	Mean Square	F-Value[y]
Fungicide (F)	1	14151095.6	290.7 *
Rep	1	559468.4	11.5 NS
Error (a)	1	48679.6	
Genotypes (G)	34	294206.4	4.41**
F×G	34	41126.1	0.62NS
Error (b)	68	66706.3	

[z]IYT = intermediate yield trial. [y]Symbols: * = significant at the 0.05 level; NS = not significant; ** = significant at the 0.01 level.

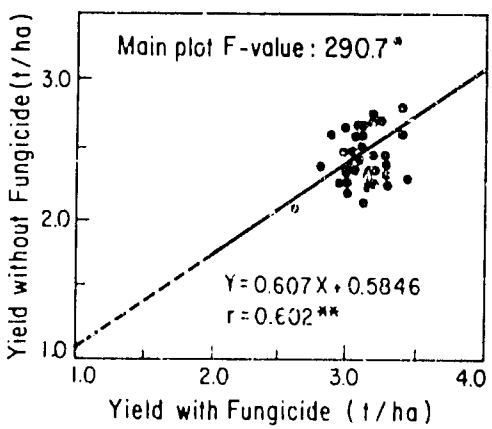


Fig. 3.
Relationship between yield with fungicide and yield without fungicide in the IYT M_7 in the February season.

Table 20. Entries selected from the international yield trial of the M_7 generation for high yield under nonfungicide treatment.[z]

G2120 Mutant Line No.	Yield (t/ha)		Days to Maturity		100-Seed Wt (g)		Rust (%)	
	WF	WOF	WF	WOF	WF	WOF	WF	WOF
111-3	3.3	2.9	113	111	9	8	5	30
24-2	3.3	2.8	112	111	8	8	3	40
35-5	3.2	2.8	114	110	9	7	3	40
39-5	3.2	2.8	113	111	9	7	5	40
96-2	3.2	2.8	112	109	8	8	0	40
69-4	3.5	2.8	113	111	8	8	3	50
52-3	3.0	2.7	113	111	8	8	3	25
71-3	3.2	2.7	113	110	8	7	3	40
G42 (Ck)	1.8	1.1	95	96	21	22	0	0
LSD (.05)								
within fungicide	0.52		2		1.0			
between fungicides	0.57							

[z]WF = with fungicide treatment. [y]WOF = without fungicide treatment.

The mean yields of mutant lines in the February and July plantings were 2.8 ± 0.26 and 2.4 ± 0.16 t/ha, respectively. The mean values for the other agronomic characters of the mutants are compared to the checks G2120 and G42 in Table 21. Although the yield of the mutants did not differ significantly from the yield of G2120, they matured 18 to 24 days earlier than G2120 (Table 22). The 13 mutant lines have been selected for evaluation in advanced yield trials in 1985. The protein content of all the mutant lines were similar in both the February and July plantings and to G2120. The oil contents of the mutants in the February planting were slightly higher than those in the July planting (Table 22).

Table 21. Mean values of agronomic traits of the M_7 generation planted in February and July.

Variable	Mean for Mutant Lines		Checks			
			G2120		G42	
	Feb.	July	Feb.	July	Feb.	July
Yield (t/ha)	2.8 ± 0.26	2.4 ± 0.16	NA[z]	2.7	1.5	1.5
Days to flowering	64 ± 1.28	44 ± 0 75	74	68.0	51.0	41.0
Days to maturity	111 ± 1.08	85 ± 1.66	NA	106.0	95.0	81.0
100-seed wt (g)	3.5 ± 0.56	5.9 ± 0.19	NA	6.9	21.6	21.4
Yield/day/hectare	25.3 ± 1.28	28.6 ± 2.78	NA	25.2	15.4	18.0
Protein (%)	44.5 ± 0.56	45.07 ± 0.35	NA	45.27	45.9	45.93
Oil content (%)	19.3 ± 0.32	18.30 ± 0.26	NA	18.22	18.0	19.56

[z]NA: Data not available

Table 22. Thirteen high-yielding mutants selected from the intermediate yield trial of the M_7 generation planted in February and July.

G2120	Yield[z] (t/ha)		DM[y]		Protein (%)		Oil (%)	
M_7 No.	Feb.	July	Feb.	July	Feb.	July	Feb.	July
69-1	3.1	2.3	112	82	42.9	45.2	19.6	18.2
69-4	3.1	2.5	112	85	44.2	44.8	19.8	18.4
96-2	3.0	2.5	111	83	45.3	45.4	19.1	18.7
24-2	2.9	2.9	112	88	43.1	45.5	19.8	18.2
71-3	2.9	2.7	111	86	44.5	44.9	19.5	18.2
17-4	2.9	2.6	112	84	44.5	45.4	19.5	18.3
84-4	2.8	2.7	113	84	44.5	44.7	19.7	18.2
61-1-3	2.8	2.5	111	87	44.4	44.5	19 2	18.4
57-1-5	2.8	2.7	112	82	44.7	45.4	19.5	18.0
34-1	2.8	2.6	112	84	44.9	45.0	19.1	18.3
101-2	2.8	2.6	112	83	44.6	45.3	19.5	18.4
54-1-2	2.8	2.5	112	84	44.6	45.5	19.1	18.1
20-4	2.8	2.7	113	82	44.3	45.1	19.5	17.9
G2120 (Ck_1)	–[x]	2.7	–	106	–	45.3	–	18.2
G42 (Ck_2)	1.5	1.5	95	81	45.9	45.9	18.0	19.6
LSD (.01)	0.48	0.45	2	5				
LSD (.05)	0.36	0.33	2	3				
Mean ± SD	2.8 ± 0.26	2.4 ± 0.16	111 ± 1.08	85 ± 1.66	44.5 ± 0.56	45.07 ± 0.35	19.3 ± 0.32	18.30 ± 0.26

[z]No significance between with fungicide spray and without fungicide spray for all the agronomic characters except yield. [y]Days to maturity. [x]This cultivar did not mature even after 117 days from planting.

Conclusion

The selected mutant lines had less photoperiod sensitivity; earlier maturity; and similar high yield potential, protein, and oil content to G2120. The most promising entries will be evaluated in the 1985 advanced yield trials.

Advanced Yield Trials

Introduction

Selections from the preliminary and intermediate yield trials (PYT and IYT) and selected promising new cultivars from national programs are entered in the advanced yield trials (AYT). Promising selections from AYT will be included in the AVRDC soybean evaluation trial (ASET).

Materials and Methods

Fifty AGS lines were evaluated in four AYTs (AYT I, 13 lines; AYT II, 11 lines; AYT III, 12 lines, and AYT V, 14 lines). Ten new accessions were evaluated in AYT IV in the February 14 planting only. Shih Shih, TN #15, AGS181, and AGS182 were used as checks for AYT I, II, and III; AGS129 and AGS182 for AYT IV; and Shih Shih, TK #5, AGS181, and AGS182 for AYT V.

All the AYTs were conducted in a randomized complete block design with four replications. AVRDC's suggested cultural practices were used with minor modifications. Observations were made on most of the agronomic characters and on disease reactions. AYT-III was evaluated in the paddy rice-stubble culture, without land preparation in the July 12 planting. All other management practices were similar to those of the trial with land preparation.

Results

Among the AGS lines evaluated, AGS 239, 248, 245, 253, 243, 261, 270, and 272 were significantly higher yielding than the high-yielding check cultivars in specific trials in the February planting (Tables 23, 24, 25). In the July planting AGS 255, 288, 283, and 290 yielded higher than the checks (Tables 26, 27). All the high-yielding lines had resistance to downy mildew, and several of them had high levels of resistance/tolerance to bacterial pustule and soybean rust.

Table 23. High-yielding lines selected from AYT I.[z]

Entry No.	Cross Designation	Yield (t/ha)[y]		Days to Maturity		Remarks[x]
		Feb.	July	Feb.	July	
AGS239	GC50047-1-12-8-6-1	2.9a	1.9bc	106	90	SR, BP, Virus
TN #15 (Ck)		2.4cde	2.0ab	101	79	
AGS181 (Ck)		2.3de	2.1a	99	80	SR

[z]AYT = advanced yield trial. [y]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [x]SR = soybean rust tolerance similar to AGS181, BP = bacterial pustule resistant; virus = showing mosaic virus symptom.

Table 24. High-yielding lines selected from AYT-II.[z]

Entry No.	Cross Designation	Yield (t/ha)[y]		Days to Maturity		Remarks[x]
		Feb.	July	Feb.	July	
AGS248	GC60120-6-7-6-6	3.0a	1.8cd	107	90	SR, BP
AGS245	GC60059-9-6-9	2.9ab	1.8cd	108	92	SR, BP
AGS253	GC60087-7-9-6-12-8	2.8abc	2.1a	104	93	SR, BP
AGS243	GC60011-4-6-11-6	2.8a-d	1.8c-e	107	94	SR, BP
AGS181 (Ck)		2.4e-h	1.9bc	98	79	SR
Shih Shih (Ck)		2.4e-h	1.7c-f	102	80	

[z]AYT = advanced yield trial. [y]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [x]SR = Soybean rust tolerance similar to that of AGS181, BP = resistant to bacterial pustule.

Table 25. High-yielding lines selected from AYT IV in the February planting only.[z]

Entry No.	Cross Designation	Yield (t/ha)[y]	Days to Maturity	Remarks[x]
AGS272	G10470	3.1a	107	BP
AGS270	G10468	3.0a	111	SR, BP
AGS182 (Ck)		2.3cd	94	SR

[z]AYT = advanced yield trial. [y]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [x]SR = soybean rust tolerance similar to that of AGS182, BP = resistant to bacterial pustule.

Table 26. High-yielding lines selected from AYT III.[z]

Entry No.	Cross Designation	Yield (t/ha)[y]		Days to Maturity		Remarks[x]
		Feb.	July	Feb.	July	
AGS255	GC60064-6-10-6-6	2.5a-e	2.2a	101	90	SR, BP
AGS182 (Ck)		2.4b-f	1.9b	94	81	SR
Shih Shih (Ck)		2.5a-f	1.7de	100	81	BP

[z]AYT = advanced yield trial. [y]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [x]SR = soybean rust tolerance similar to that of AGS182; BP = resistant to bacterial pustule.

Table 27. High-yielding lines selected from AYT V.[z]

Entry No.	Cross Designation	Yield (t/ha)[y]		Days to Maturity		Remarks[x]
		Feb.	July	Feb.	July	
AGS288	GC50106-47-6-6-6	2.7a	2.3a	106	88	BP
AGS283	GC60053-7-7-6-8	2.4abc	2.2a	107	87	BP
AGS290	GC60087-7-9-6-10-31	2.4abc	2.2a	103	90	BP
AGS182 (Ck)		2.4abc	2.0bc	94	75	SR
Shih Shih (Ck)		2.2c	1.8ef	100	80	BP

[z]AYT = advanced yield trial. [y]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [x]BP = resistant to bacterial pustule; SR = soybean rust tolerance similar to that of AGS182.

Upon completion of the September-planted trial, a combined analysis of all the three seasons will be done to evaluate the adaptability to more than one season.

In AYT III in the rice-stubble culture with and without tillage, the yields of the entries in the tillage plots were consistently higher, from 0.5 to 23%, over the no-tillage plots with a mean increase in yield of 6%. AGS255 was significantly higher yielding than the check cultivars in the tillage plots; but although it was the highest yielder in the no-tillage rice-stubble culture, its yield difference with the check was not significant. The correlation between yields in the no-tillage and tillage plots was highly significant ($r = 0.822^{**}$), suggesting that the high-yielding entries in tillage also gave high yields without tillage. Therefore, from a one-season trial, it appears that one breeding program is sufficient to develop lines for two different management conditions.

Conclusion

Several high-yielding, disease-resistant AGS lines have been identified for inclusion in the next ASET. Although there is good correlation between yields in no-tillage and tillage treatments, additional seasons and location data are necessary to confirm the findings. This will be done in 1985.

Continuous Soybean Cropping

Introduction

Soybean is continuously cropped on the same piece of land in some countries, like Indonesia. A three-season experiment was initiated in 1982 and continued in 1983 and 1984 to determine the value of continuous soybean cropping, particularly on grain yield, and any associated problem, if any.

Materials and Methods

A narrow leaflet selection, AGS129 and a broad leaflet selection AGS 154 were planted on January 24, June 22, and September 26 in a randomized complete block design with four

replications. The plot size was 5 × 10 m. The spacing was 50 cm between rows and 10 cm between hills. Upon emergence the seedlings were thinned to two plants per hill in the January and June plantings and three plants per hill in the September plantings. Observations were recorded on yield and days to maturity.

Results

The seventh, eighth, and ninth soybean crops were successfully harvested from the same piece of land in 1984. There were no significant differences in yield between the two cultivars in any of the three crops. The yield of the January crop was the highest, followed by the June and then the September crop (Fig. 4). Depending upon the cultivar the January crop was 38 to 41% higher than the June crop which was 26 to 27% higher than the September crop. The total yields of the three crops were almost similar, 6.6 t/ha for both AGS 129 and AGS 154. Of the total yield, as in the previous years, the January and June crops constituted 75% (Fig. 5).

In 1984 more rainfall in all the three crops reduced the yield. For example, the June crop received 814 mm rainfall in 1983 and 971 mm in 1984. Photoperiod and temperature in both 1983 and 1984 were similar (Figs. 6 and 7, see next page), except that in 1984 the cool weather was longer and so, early planting resulted in poor early growth.

Conclusion

Since the total yield this year was slightly lower than that of the past two years, this experiment will be continued for one more year before being terminated.

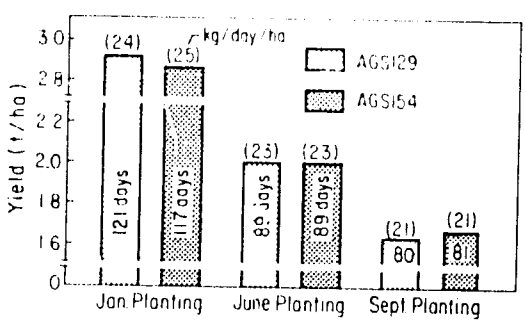


Fig. 4. Yields of two soybean selections in three consecutive plantings (values in parenthesis are yield day^{-1} ha^{-1}), 1984.

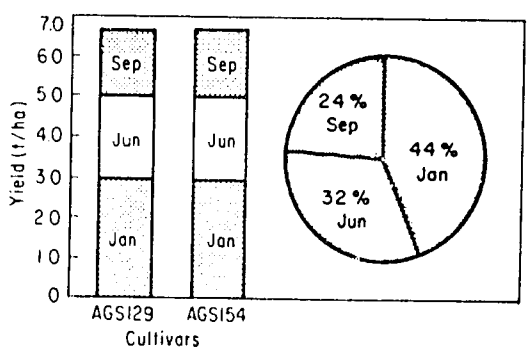


Fig. 5. Yields of two soybean selections in continuous cropping for two seasons in 1984.

Genotypic Variation for Shade Tolerance in Soybean

Introduction

Intercropping soybean with annual and perennial crops is common in the tropics. Intercropped soybean is subject to varying levels of shading. To determine the variability for shade tolerance available in the AGS lines, an experiment was initiated in 1983 and continued in 1984.

Materials and Methods

Six AGS lines (AGS 34, 59, 80, 106, 129, and 145) were evaluated under a nylon-netting shade and without shading on a split-plot design. The plot size was 3 × 1 m and two rows

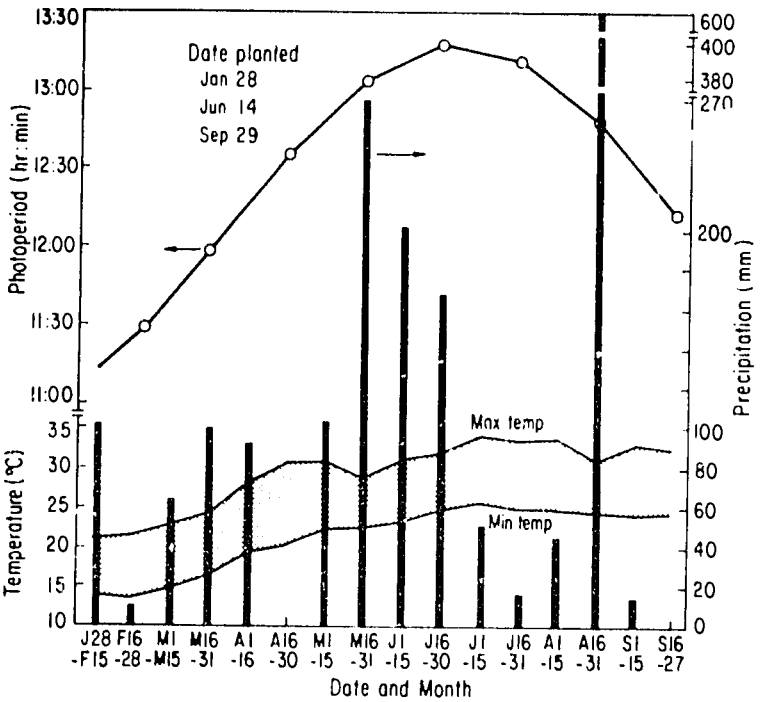


Fig. 6. Maximum and minimum temperatures, rainfall, and photoperiod at AVRDC in 1983.

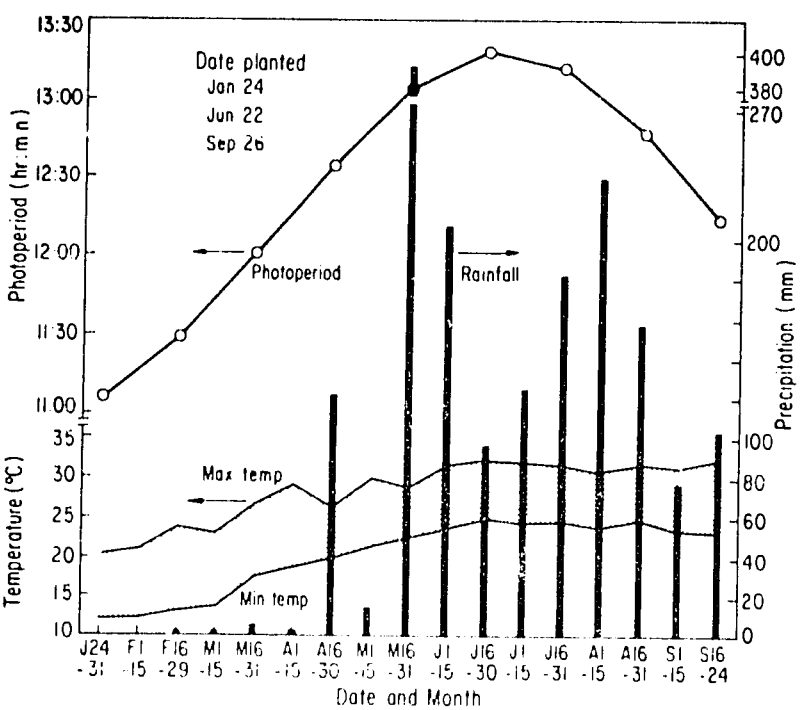


Fig. 7. Maximum and minimum temperatures, rainfall, and photoperiod at AVRDC in 1984.

per plot were used. Each entry was replicated twice. The experiment was planted on February 21 and July 18, 1984. Observations were made on yield, days to R_1 and R_8, plant height at R_1 and R_8, 100-seed weight, seed quality, and lodging. The shading treatment was imposed at seedling emergence. Light transmission was measured with a Lambda LI-185 photometer and an LI-190S quantum sensor.

Results

Light intensity was 7 to 10% higher in the July than in the February planting. Regardless of the season, light density under netting was 52 to 53% of the unshaded treatment (Table 28).

There was a significant difference in yield between the netting and the unshaded treatments in both the February and July plantings. The difference between genotypes for shade tolerance was also significant. Yield reduction due to netting varied from 31 to 60% in February and 24 to 51% in July planting. AGS129 and AGS80 appeared to be tolerant to shading in both plantings (Table 29). AGS106 was susceptible to shading in both seasons; AGS34 was susceptible to shading in February but tolerant in July. In several instances the 1984 and 1983 results were contradictory with regard to AGS 80 and 129.

In both seasons there was no relationship between yields with and without shading. However, days to maturity (DM) and 100-seed weight (SW) with and without shading had significant correlation (DM-February, 0.98**; July, 0.92**; SW-February, 0.90**; July, 0.94**). The 1983 and 1984 data will be analyzed with those of September to determine the interaction between seasons, years, and genotypes.

Conclusion

Results obtained so far suggest that a selection for shade tolerance has to be done for specific seasons, locations, and situations. In short, shade tolerance appears to be dependent on environment. This experiment, therefore, will be repeated for one more year and maybe in two different locations.

Table 28. Light density (microeinsteins $m^{-2}Sec^{-1}$) in netting and unshaded treatments during the flowering stage in two seasons.

Rep.	Light Density			
	netting		unshaded	
	Feb.	July	Feb.	July
1	660	750	1,350	1,410
2	600	780	1,200	1,410
3	690	690	1,380	1,440
4	780	780	1,350	1,380
Mean ± SD	683 ± 75	750 ± 42.43	1,320 ± 81.24	1,410 ± 24.49

Table 29. Yield and yield-reduction percentage due to netting in soybean, 1984.

Entry	Yield (t/ha)				% Yield Reduction Due to Netting(%)	
	netting		unshaded			
	Feb.	July	Feb.	July	Feb.	July
AGS80	1.9	1.6	2.8	2.1	31	24
AGS129	1.9	1.7	2.8	2.4	34	30
AGS145	1.2	1.3	1.8	2.2	33	41
AGS59	1.4	1.9	2.9	2.9	51	34
AGS106	0.8	1.0	1.8	2.1	55	51
AGS34	1.4	1.3	3.6	2.1	60	38

Sole-Cropping Compared to Intercropping

Introduction

Soybeans are sole-cropped and intercropped in many countries. From a preliminary screening of AGS lines in 1983, 55 entries were selected for further evaluation. From these, selected entries were tested for intercropping in specific seasons.

Materials and Methods

The experiment was conducted with 14 AGS lines and Shih Shih, a local cultivar as the check. A randomized complete block design with two replications was used in evaluating the genotypes under sole-cropping and under intercropping in independent trials. The plot size was 3 × 1 m. In the intercropping experiment one row of soybean was alternated with one row of corn, cv. Tainung 351. Plantings were done on February 21 and July 18, 1984. The spacing between rows was 50 cm. Data were collected for grain yield, days to R_1 and R_8; plant height at R_1 and R_8, seed quality, and lodging.

Results

The yields of corn in both the February and July plantings did not differ significantly when intercropped with any of the 14 AGS lines. However, there were significant yield differences among the AGS soybean lines in both seasons. Four AGS lines gave high yields of about 1 t/ha yield under intercropping in February (Fig. 8). It is interesting to note that AGS34 was also found to be shade tolerant in this year's trial. Five lines gave 2.2 to 2.4 t/ha under intercropping in the July planting (Fig. 9). Six other lines gave about 1.6 t/ha in intercropping in the same season compared to Shih Shih which was one of the lowest yielder. The yield of corn under intercropping was lower in July than that in February (Table 30). The low yield was likely due to damage by heavy rain and wind. The same trend in yield was also observed in the 1983 July and February corn crops.

Conclusion

In the July season the yield reduction of soybean intercropped with corn was less than that of the February season. Genotypes with high yield potential under intercropping can be selected. In order to fully understand the potential value of intercropping, soybean trials should be conducted that include the economics of the production system to show how it compares with sole-cropping in different seasons and locations.

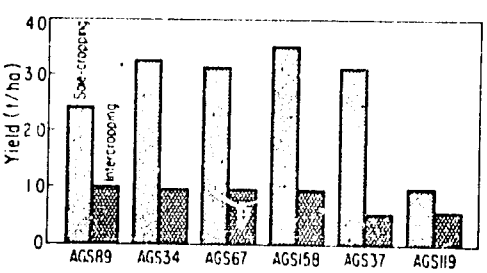


Fig. 8. Yields of selected soybean lines under solecropping and intercropping with corn in the February 1984 planting.

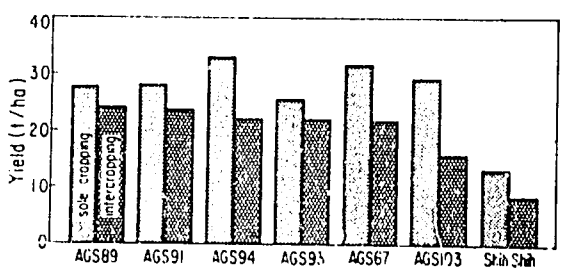


Fig. 9. Yields of selected AGS lines under solecropping and intercropping with corn in the July 1984 planting.

Table 30. Yield range and mean under sole-cropping and intercropping of soybean in February and July 1984.

Crop	Yield (t/ha)			
	Sole Crop		Intercrop	
	Feb.	July	Feb.	July
Corn	–	–	1.7 – 2.5 (2.2)	0.25 – 0.94 (0.49)
Soybean	1.1 – 3.5 (2.6)[z]	1.3 – 3.3 (2.5)	0.5 – 1.1 (0.85)	0.9 – 2.4 (1.7)

[z]Mean.

Response to Minimum and Maximum Management Inputs

Introduction

Soybeans are invariably grown with minimum inputs in the tropics. To determine whether there are varietal differences in response to minimum and maximum input in different seasons and to learn whether separate breeding programs are required for different management situations, experiments were conducted at AVRDC in the past. To understand locational effect, such trials were conducted in Thailand in cooperation with Thai scientists.

Materials and Methods

Eleven AGS lines and Shih Shih were included in the trials. The experiment was conducted at Phitsanuloke (planted on July 21, 1983) and Nakon Sawan (planted on July 29, 1983) in Thailand. For maximum input, fertilizer was applied at 20 kg N, 60 kg P, and 40 kg K/ha. Hand weeding was done at 15 and 30 days after germination. Since it was a rainy season no irrigation was provided. Insecticides and fungicides were applied when required. For the minimum input treatment, no fertilizer or other inputs were provided. Observations were recorded on grain yield, days to R_8, plant height at R_8, number of branches, number of nodes and pods, 100-seed weight, lodging, and shattering.

Results

The yield differences between genotypes were significant in all the trials at both locations. The yield gap between maximum and minimum inputs was 14% in Phitsanuloke. However, in Nakon Sawan the mean yield under minimum input was 11% higher than that of maximum input, suggesting that there was practically no difference in yield between the two input treatments (Fig. 10). AGS lines with high yields in each location under two different treatments are given in Table 31. AGS 68, 66, and 62 appear to be suitable for both minimum and maximum input situations.

Similar to results obtained at AVRDC, grain yield under minimum input correlated well with yield under maximum input in both locations ($r = 0.96^{**}$ and 0.98^{**}), suggesting that selection for high yield can be done at either of the two management conditions regardless of which management input situation the selected genotype is intended for use.

Conclusion

Although the average yields are low for various genotypes, the yield gap between maximum input and minimum input vary with locations. Nonetheless, one breeding program is sufficient to develop selections suitable for both management conditions.

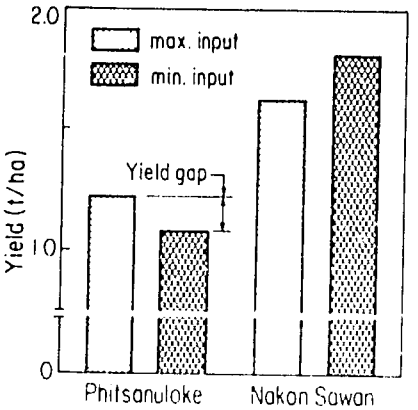


Fig. 10.
Yield differences between maximum and minimum inputs at two locations in Thailand in the July 1983 planting.

Table 31. Genotypes highly responsive to maximum input management and those with high yield potential under minimum input in different locations.

Response	Location					
	Pitsanuloke			Nakon Sawan		
	genotype	yield (t/ha)	DM[z]	genotype	yield (t/ha)	DM[z]
Responsive to maximum input	AGS71	1.8	95	AGS62	2.0	86
	AGS17	1.7	90	AGS68	1.9	97
				AGS66	1.9	81
High yielding under minimum input	AGS59	1.6	90	AGS66	2.3	79
	AGS68	1.4	95	AGS62	2.2	87
	AGS66	1.3	80	AGS71	2.1	97
				AGS59	2.0	90
				AGS68	2.0	96

[z]DM = days to maturity.

International Cooperation

A total of 58 selections from the AVRDC soybean evaluation trials, 796 breeding lines, 914 accessions, and 28 others were distributed to 121 cooperators in 39 countries.

After three years of testing by the Tainan District Agricultural Improvement Station, the farmers in I-Chu, Yen-Shui, and neighboring "hsiens", multiplied the seeds of AGS66 and slowly increased the area planted to AGS66. About 100 ha was planted in February and July. AGS66 has not been formally released. The seeds of AGS66 cannot be stored under room temperature for more than a couple of months; it loses viability rapidly. Crosses have already been made to improve its seed quality. AGS66 is also promising in the Philippines, Saudi Arabia, and Japan; but its seed size is too small for the Japanese market (Table 32).

AGS8 was reported from St. Lucia as an excellent yielder and, therefore, a request for seeds to plant on 5 ha was received from PLENTY in St. Lucia. However, due to seed shortage we sent only 10 kg.

G10380 gave the highest yield in an observational trial by cooperators in Brazil (Table 32). Seven entries from AVRDC have been identified by the Chinese Overseas Technical Mission team to have a yield potential of 2.0 to 2.7 t/ha in Indonesia. Notable among them are G2120 M_7 (the early maturing mutant from G2120), AGS205, AGS171, GC60062-8-7-6, and G10180. The national program in Indonesia will be encouraged to test these entries at strategic locations to confirm their potential.

AGS160 appears to be promising in Pakistan, Philippines, Venezuela, and Zaire. AGS 143 and 167 are also promising in the Philippines and Venezuela (Table 32). In the Philippines, POP reported that after several years of evaluation, AGS73 (EGYS-73) may be released as a Seed Board cultivar probably in 1985.

Promising selections from the cross between the AVRDC narrow leaflet line GC30228-9 and the local cultivar in Zimbabwe is currently entering multilocational trials. Some of the photoperiod-insensitive accessions sent to Zimbabwe have given 3.6 to 3.8 t/ha in 82 to 89 days which will be utilized in their breeding program (Table 32).

After evaluating 37 vegetable types, The W. Atlee Burpee seed company of California reported that eight entries had good size and taste, as well as yield potential, which need to be evaluated in replicated trials (Table 33).

Results from an observational trial in Korea showed Taisho Shiroge as the best vegetable soybean. It will be evaluated further in 1985.

In Shillong, India, G5497 was reported to have the lowest rust infection compared to AGS 181, 182, 183, and GC60245-8-1-1-12-6-9 in the June 1984 planting.

In a study on G2261 Miss Covell, an undergraduate student at Reading, England estimated the thermal sum (day degrees above base temperature, 4°C) for 50% and 70% germination to be 32° and 35.5°C for soybean.

Table 32. Summarized results of international trials.

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity[z]	Seed Quality[z]	100-Seed Wt (g)[z]	Remarks[y]
Brazil	G10380	6.2	119	2	24.0	P: Nov. 14, 1983
OCEPAR	GC50265-2-9-6-8	4.3	118	3	21.4	T: 27 Rep: 1
	GC50245-8-1 -12-6-9	4.2	120	1	13.0	
	Bossier (Ck_1)	5.4	128	2	15.6	
	FT-2 (Ck_2)	4.2	130	1	18.0	
	Parana (Ck_3)	3.3	111	2	16.8	
Burma	AGS129	1.2b	94b	4ab	16.2ab	P: Aug. 17, 1983
Lat. 19°15'10"N	AGS19	1.1bc	87c	4ab	15.4bc	T: 12
Alt. 102 m	AGS124	1.1bc	94b	3cd	14.7cd	
U PE MG Thein	GM-82-2 (Ck_2)	1.8a	106a	2f	17.3a	
	GM-82-1 (Ck_1)	0.9bcd	87c	4.3a	13.9d	
Costa Rica	AGS124	2.8ab	89b	2ab	16.5de	P: Sep. 8, 1983
Lat. 10°26'	AGS129	2.6ab	87bc	2ab	17.9c	T: 11
Alt. 17 m	AGS65	2.6ab	89b	1b	16.7d	
T. S. Toung	AGS167	2.3ab	80de	2ab	19.4b	
	AGS143	2.3ab	77e	2ab	17.5c	
	AGS162	2.2ab	76e	2ab	15.8e	
	Local Ck_1	2.8a	94a	2ab	18.0c	
	Local Ck_2	2.6ab	89b	2ab	21.6a	
Haiti	AGS129	2.9ab				P: Oct. 1983
Lat. 18°N	AGS130	2.7abc				T: 12
Wally Turnbull	AGS85	2.6abcd				
	AGS29	2.6abcd				
	AGS17	2.6abcd				
	Local Ck	3.1a				
Indonesia	AGS205	2.3	97		12.6	P: Jan. 3, 1984
W. H. Wang	G2120 (Ck_1)	2.1	115		7.4	T: 3
	No. 1248 (Ck_2)	1.2	93		9.7	Rep: 2
Donald R.	G2261	0.63	79			P: Apr. 4, 1984
Schmidt	Lokon (Ck)	0.24	79			T: 9
W. H. Wang	AGS171	1.7	115		13.8	P: Sep. 5, 1983
	AGS205	1.6	103		12.2	T: 4
	G2261	1.4	98		13.2	Rep: 2
	Local Check	0.81	94		9.6	
Lat. 11°S	AGS79	1.00a	99a	2	18.1bc	P: Jan. 12, 1984
Alt. 150 m	AGS162	0.89ab	97c	1.5	18.3bc	T: 10

Table 32. (Continued)

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity[z]	Seed Quality[z]	100-Seed Wt (g)[z]	Remarks[y]
Site: Mjo	AGS65	0.70abc	97c	2.7	19.8b	
Colin Piggin	AGS167	0.60abc	97c	2.3	23.4a	
	AGS19	0.60abc	98ab	2.8	19.6bc	
	AGS129	0.60abc	97c	2.7	18.0bc	
	ORBA (Ck)	0.61abc	98ab	2.7	13.8d	
Lat. 3°1′	AGS143	0.86a	94d	2b	15.5ab	P: Dec. 28, 1983
Alt. 20 m	Local Ck_1	0.90a	100a	2b	10.0f	T: 11
Site: Kisaran	Local Ck_2	0.80a	100a	2b	10.0f	
I. Tataming						
W. H. Wang;	i) G2120 M_7	2.6	99	9		P: July 7, 1984
Ir. Supatmi	GC60062-8-7-6	2.2	104	12		T: 6
	AGS129	1.9	98	19		Rep: 2
	AGS66	1.5	107	16		
	Hualien No. 1	1.7	97	24		
	No. 1248 (Ck)	1.6	98	10		
	ii) G2120	2.8	115	8		P: Apr. 4, 1984
	G10180	2.7	105	9		T: 5
	G10182	0.9	98	16		Rep: 1
	G10183	0.7	88	16		Moisture was
	G10181	0.4	88	16		limiting (drought)
Japan	AGS66 '80	2.2	118	13		T: 19
T. Yoshida	'81	4.9	126	19		
	'83	2.3	118	12		
	AGS62 '80	3.6	114	20		
	'81	3.5	115	18		
	'83	3.4	112	14		
	Enrei (Ck) '80	3.2	117	36		
	'81	3.4	128	27		
	'83	3.0	107	29		
Malawi	AGS129	3.3a	99bcd	1e	18.2bcd	P: Dec. 30, 1983
Lat. 14°S	AGS19	3.2a	99bcd	1e	17.5cd	T: 12
Alt. 1080 m	AGS124	3.0ab	95ef	1.5cde	17.6cd	
C.A.M. Phanga-	ORRIB (Ck_1)	3.1ab	101abc	1e	19.0ab	
phanga;	Hardee (Ck_2)	3.0ab	102abc	1.3de	19.7a	
L. K. Gondwe						
Pakistan	AGS160	1.0a	114d		9.7bc	P: July 20, 1983
Lat. 34°N	AGS162	0.8ab	106f		10.1bc	T: 12
Alt. 118 m	Bragg (Ck_1)	0.5cd	115cd		10.6b	
Tila Mohammad	William (Ck_2)	0.2e	96h		10.6b	
Philippines	AGS65	1.6a	103bc	3.0a	18.8ab	P: Aug. 12, 1983
Lat. 6°7′N	AGS160	1.5ab	107a	3.8a	15.3de	T: 12
Alt. 15 m	Local Ck_1	0.9c	100d	3.0a	12.3gh	
Site: Lagao	Local Ck_2	1.2bc	100d	2.8a	11.8h	
Botanique Phil.						
Inc.						
Lat. 14°13′N	AGS167	1.2a	79efg	2.8bcd	16.8a	P: Feb. 9, 1984
Alt. 23 m	AGS160	1.2a	81cde	2.8bcd	10.8fg	T: 12
Site: Los Baños	AGS66	1.2a	72h	2.5cd	11.5ef	
R. K. Pandey	AGS143	1.1ab	78g	2.3d	15.5ab	
	AGS129	1.1ab	82cd	3.5ab	13.3cd	
	AGS162	1.0abc	81cde	3.3ab	14.5bc	
	Local Ck_2	0.8cd	79efg	2.8bcd	14.5bc	
	Local Ck_1	0.6d	108a	4.0a	9.0h	
	Clark 63 (Ck_3)	0.4e	90b	4.0a	16.8a	
L. Empig	AGS143	2.3	73.	18	3	P: Feb. 2, 1984

Table 32. (Continued)

Country Location Cooperator	Cross No. or Name	Yield[z] (t/ha)	Days to Maturity[z]	Seed Quality[z]	100-Seed Wt (g)[z]	Remarks[y]
(San Miguel	AGS129	1.3	75	18	4	T: 7
Corporation)	UPLSY2 (CK)	1.9	83	20	4	Rep: 3
Saudi Arabia	AGS29	4.2	117		12.0	P: May 20, 1982
Lin Jiunn-Yann	AGS130	4.1	110		18.0	T: 6
	AGS66	4.0	107		11.6	Rep: 4
	Davis (Ck_1)	4.5	130		13.6	
Venezuela	AGS65	2.0a	103b	3.5b	19bc	P: Oct. 4, 1983
Lat. 8°50'N	AGS160	1.9a	94cd	5.0a	16e	T: 10
Alt. 126 m	AGS79	1.8a	101b	4.8a	15e	
Porfinio	AGS19	1.7a	97c	4.5a	17d	
Hernandez	AGS129	1.6a	97c	5.0a	18cd	
	AGS143	1.6a	91d	5.0a	20b	
	AGS124	1.6a	101b	4.8a	17d	
	AGS162	1.6a	91d	5.0a	18cd	
	AGS167	1.5a	91a	4.8a	22a	
	Local Ck	1.9a	94cd	2.5c	23a	
Zaire	AGS29	1.3a	129b	3.3a	15.5c	P: Sep. 15, 1982
Lat. 2°18'S	AGS130	1.3a	129b	3.0a	16.5bc	T: 14
Alt. 1731 m	G9646	1.1ab	125bc	3.0a	15.0c	
Site: Mulungu	AGS58	1.1ab	120bc	3.0a	15.5c	
Quyen Nguyen;	AGS12	1.0ab	120bc	2.8a	15.3c	
Elukesu						
Lat. 2°18'S	AGS160	1.3ab	149c	2.8ab	18ef	P. Sep. 27, 1983
Alt. 1731 m	AGS19	1.2abc	140d	3.5a	16gh	T: 12
Site: Mulungu	Imperial (Ck_1)	1.5a	149c	2.5b	32a	
Quyen Nguyen;	Doka (Ck_2)	1.1b-e	183a	3.0ab	20cde	
Elukesu; Nkusu;						
Eugide; Bakulikira						
Zambia	G9645	1.2a	97abc	1.5bc	14ef	P: Jan. 7, 1983
Lat. 16°1'S	AGS9	1.2ab	91b-e	1.0c	13.3f	T: 14
Alt. 1057 m	AGS58	1.2ab	95a-d	1.5bc	21a	
J. Joshi	AGS29	1.1abcd	93a-e	1.0c	16cd	
	AGS129	0.8a-e	88cde	1.0c	16cd	
Zimbabwe	P500-5-17	4.2				P: 1983-1984
J. S. Tichagwa	P500-5-6	4.2				T: 184
	P500-5-99	4.1				The test was only
	P500-5-89	4.1				for preliminary
	P500-5-130	4.1				variety trial
	Sable (Ck_1)	3.6				
	Oribi (Ck_2)	3.6				
	Hood (Ck_3)	3.4				
	Hardee (Ck_4)	2.9				
J. R. Tatters-	AGS147	4.0	125	3	14.4	P. Nov. 25, 1983
field	AGS140	3.8	138	2	16.2	T: 52
	Oribi (Ck_1)	3.4	122	2	14.8	Rep: 1
	Duiker (Ck_2)	4.9	131	2	17.6	
J. S. Tichagwa	G141	3.8	85	3	19.4	P: June 12, 1983
	G2502	3.8	89	3	25.7	T: 36
	G166	3.8	85	2	15.6	Rep: 1
	G222	3.7	89	3	19.6	
	G7104	3.7	89	3	23.3	
	G6883	3.6	85	2	16.9	
	G3906	3.6	82	3	19.4	

[z]Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test. [y]P = date planted, T = total no. of entries, Rep = replications

Table 33. High-yielding and suitable vegetable soybean tested at U.S.A. in 1983.[z]

Acc. No.	PI No. or Name	Days to Maturity
G5087	Cobb	114
G5654	FC19.979-1	115
G6472	PI86.137-1	112
G6852	PI96.550	121
G7082	PI196.151	87
G10348	Ohsode Early	87
G10350	Raityo	85
G9053 (Ck)	Tzurunoku	120

[z]Planted date: June 2, 1983; total entries: 37; result: the varieties showed good plant size, big beans, sweet bean taste, and good yield potential.

IITA/IRRI/AVRDC Cooperation

AVRDC provided 197 AGS lines for evaluation at IRRI by the IITA legume agronomist/breeder. The experiment was planted on February 9, 1984 at IRRI's UQ-3 field. Two treatments were imposed: without irrigation (but receiving 317.7 mm rainfall water) and with irrigation (515.1 mm including rainfall) (Fig. 11) . Among 197 entries AGS19 did not germinate and AGS 184, 185, and 188 had poor plant stand. Twenty-eight entries appeared to have severe mosaic-like symptom and, therefore, were discarded.

The maximum and minimum temperatures and the rainfall pattern during the trial period are shown in Fig. 11. Among the 145 entries, nine with drought tolerance are given in Table 34. Fifty percent of the entries matured in 70 to 80 days, 48% matured in 81 to 90 days, and four entries matured in 101-110 days (Fig. 12).

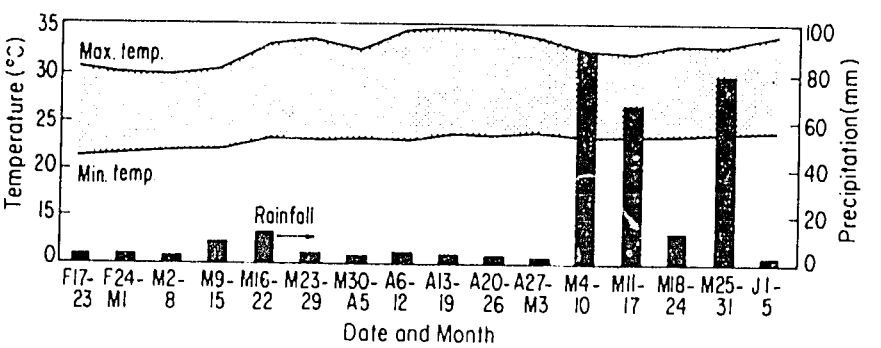


Fig. 11. Maximum and minimum temperatures and rainfall pattern during the drought-tolerance screening trial at IRRI, Los Banos, Philippines, 1984.

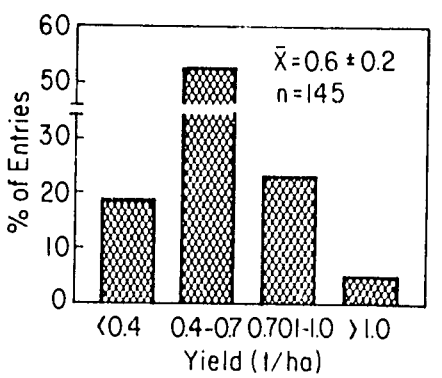


Fig. 12.
Frequency distribution for days to maturity of 145 AGS lines evaluated at Los Banos, Philippines.

Table 34. Nine high-yielding lines selected from 197 AGS lines for drought tolerance in Los Baños, 1984.[z]

Cultivar Name	Yield (t/ha) without irrigation	Yield (t/ha) with irrigation	Days to Maturity	Leaf Roller[y]	Soybean Mosaic Virus[x]
AGS155	1.2	1.6	80	2	2
AGS170	1.2	2.2	86	1	2
AGS163	1.2	2.1	76	1	3
AGS154	1.1	1.7	76	1	2
AGS156	1.1	1.5	80	1	3
AGS126	1.0	1.8	76	1	2
AGS218	1.0	1.8	82	1	2
AGS175	1.0	1.8	83	1	3
AGS160	1.0	1.6	80	1	3
Mean	0.60	1.27	80.8		
Standard deviation	0.21	0.36	4.5		

[z]Cooperator: R. K. Pandey. [y]Leaf roller rating. 1 = no damage; 2 = moderate damage; 3 = sever damage. [x]Soybean mosaic virus rating: 1 = resistant; 2 = with occasional diseased plants; 3 = 10% diseased plant; 4 = 11-50% diseased plant; 5 = nearly all the plants have symptoms.

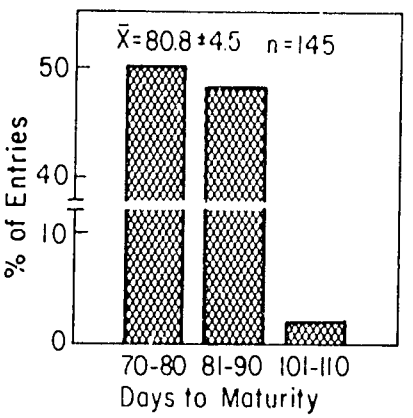


Fig. 13.
Frequency distribution for yield of 145 AGS lines in Los Banos, Philippines.

AGS 26, 28, 102, 116, and 229 had severe leaf roller damage, while 90% of the entries appeared to have very little injury. Yield percen-tage of the entries without irrigation are shown in Fig. 13.

There was a highly significant correlation between yields with and without irrigation ($r = 0.4898^{**}$), indicating that selections with high yield under irrigation will give high yields without irrigation.

Cooperation with ICA, Palmira, Colombia

A total of 228 AGS lines were sent to Dr. Gilberto Bastidas Ramos at ICA, Palmira, Colombia. They were planted in an observational trial. Each entry was planted in a 6 m^2 plot. Observations were recorded for nine agronomic characters, including yield. Disease ratings were recorded for bacterial pustule, bacterial blight, frog eye leaf spot, downy mildew, and common mosaic virus. Ratings were made on a 1 (resistant) to 5 (susceptible) scale.

Ten high-yielding entries and their characters are given in Table 35. The frequency distribution of the AGS lines in different disease ratings for different diseases showed that moderate to high levels of resistance were present in a number of AGS lines for all the diseases (Table 36).

Table 35. Ten high-yielding AGS lines selected from 228 lines planted in Colombia in 1984.

AGS No.	Yield (t/ha)	Days to Maturity	Lod[z]	Shat[y]	Disease[x]				
					BP	BB	FLS	DM	CV
AGS79	3.8	90	1	2	4	4	2	4	2
AGS67	3.7	91	3	1	3	3	3	4	5
AGS120	3.7	92	4	1	2	2	2	4	1
AGS160	3.6	90	1	2	3	3	2	3	3
AGS144	3.6	87	1	1	3	3	2	2	1
AGS76	3.5	90	3	1	2	2	2	3	2
AGS57	3.5	91	4	2	2	2	2	4	2
AGS32	3.5	85	2	2	3	2	2	4	3
AGS37	3.5	92	2	1	2	2	2	3	2
AGS175	3.4	89	2	1	3	3	2	3	2

[z]Lodging 1 = erect, 4 = lodging. [y]Shattering 1 = nonshattering, 4 = shattering. [x]BP: bacterial pustule; BB: bacterial blight; FLS: frog eye leaf spot, DM: downy mildew; CV: common mosaic virus.

Table 36. Percentage of AGS lines in different disease rating categories for different diseases in Colombia, 1984.

Disease	Ratings[z]				
	1 (Resistant)	2	3	4	5 (Susceptible)
Common mosaic virus	13.6 (31)	63.2 (144)	18.9 (43)	3.9 (9)	0.4 (1)
Bacterial blight	0.4 (1)	38.6 (88)	47.0 (107)	14.0 (32)	0.0
Bacterial pustule	0.4 (1)	34.2 (78)	51.8 (118)	13.6 (31)	0.0
Frog-eye leaf spot	3.1 (7)	79.5 (182)	16.2 (37)	0.9 (2)	0.0
Downy mildew	15.0 (34)	36.0 (81)	29.0 (67)	20.0 (46)	0.0

[z]Figures in parenthesis refer to the number of entries.

AVRDC Soybean Evaluation Trials (ASET) from Cooperators

Ten AVRDC *Glycine* selections were included in the 1983 ASET (Table 37). The cooperators were requested to include one or two local cultivars as checks. Data received from 11 cooperators have so far been analyzed (Table 38). Additional data are being received and analyzed. The mean yield of 11 sites are shown in Table 39. AGS 66 and 160 have either significantly outyielded or were earlier maturing than the check cultivars in three sites each.

In many locations the yields of the trial were affected by cows, snails, chickens, lack of water, or improper pest-and disease-management practices. In some countries, like Mauritius, the seeds were destroyed by the Ministry of Agriculture due to change in quarantine regulations.

Table 37. Pedigree of soybean cultivars grown in the AVRDC soybean evaluation trial (ASET) in 1983.

Cultivar	Pedigree
AGS19	Shih Shih x SRF400
AGS65	66-D-20 x CH #2
AGS66	Forrest x Shih Shih
AGS79	KS514 x Palmetto
AGS124	Clark 63 x CH #3
AGS129	Shih Shih x SRF400
AGS143	Single plant selection from KS725
AGS160	PI227224 x AGS2
AGS162	Clark 63 x 64-4
AGS167	64-4 x 64-62

Table 38. List of cooperators who returned the data for the AVRDC soybean evaluation trial (ASET) in 1983.

Region	Country	Trial No.	Name	Address
Africa	Zaire	83-12	Quyen Nguyen, Elukesu, Nkusu, Eugide, & Bakulikira	Programme National Legumineuses
	Malawi	83-34	C.A.M. Phangaphanga & L. K. Gondwe	P.O. Box 158, Lilongwe
Asia	Burma	83-2	U PE MG Thein	Food Legumes Div., ARI, Yezin Pyimana
	Indonesia (1)	83-28	Colin Piggin & S. S. Field	P.O. Box 36, Kupang, Ntt
	Indonesia (2)	83-36	I. Tataming	P.T. Uniroyal, Kisaran, North Sumatra
	Pakistan	83-20	Tila Mohammad	NIFA, Tarnab, Peshawar
	Philippines (1)	83-14	Botanique Phil. Inc.	Lagao, Gen. Santos City
	Philippines (2)	83-49	R. K. Pandey	IRRI, Los Baños, Laguna
Latin America	Venezuela	83-22	Porfinio Hernandez	Linellez, Guanane 33-23
	Colombia	83-51	Gilberto Bastidas Ramos	ICA, Palmira AA 233
	Costa Rica	83-19	T. S. Toung	Mision China, Apartado 120, Canas, Guanacaste

Table 39. Performance of AGS lines and check cultivars in the ASET in different countries.

Country	Yield (t/ha)			Outstanding Entries[z]
	mean	range	check cultivars	
Burma	1.0	0.7-1.8	0.9 and 1.8	None
Colombia	2.8	2.3-3.1	2.4 and 2.7	66, 79, 162
Costa Rica	2.5	2.2-2.8	2.6 and 2.8	124, 129
Indonesia (1)	0.5	0.2-1.0	0.6	79
Indonesia (2)	0.5	0.2-0.9	0.8 and 0.9	143
Malawi	2.7	1.0-3.3	3.0 and 3.1	129, 19
Pakistan	0.5	0.2-1.0	0.2 and 0.5	160, 162
Philippines (1)	1.0	0.3-1.6	0.9 and 1.2	65, 160
Philippines (2)	0.9	0.3-1.2	0.3, 0.6 and	167, 160, 66,
Venezuela	1.7	1.4-2.0	Lost	65
Zaire	1.1	0.9-1.5	1.1 and 1.5	66

[z]ASET AGS entries significantly outyielded or were better than the checks in other traits.

Since additional locations are sending the data, a combined analysis of the data will be done which will be included in a separate ASET report to be published.

The common crop rotation in the ASET-reporting countries appeared to be soybean followed by corn. Sorghum followed by soybean and *Phaseolus* beans followed by soybean were indicated in some places (Fig. 14).

Cooperation with the Korean Soybean Breeding Program

As in the past, seeds from five crosses were advanced by the single-seed-descent (SSD) method. The F6 lines from the pedigree and SSD method were also harvested to compare the different methods that rapidly advanced the generations and to test the usefulness of the new technique in Korea in 1984 and 1985. Seeds of F3 bulks and selected entries for demonstration trials were also multiplied. A total of 83 kg of seeds were shipped to Korea (Table 40).

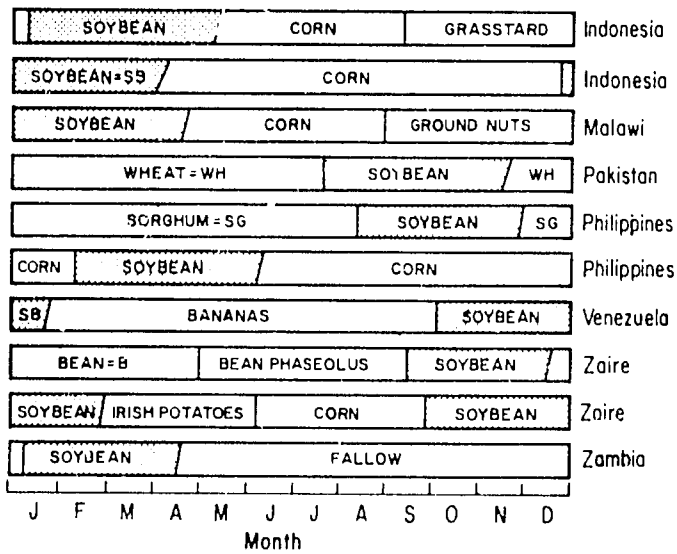


Fig. 14.
Cropping systems with soybean in countries conducting ASET from 1982 to 1983.

Table 40. Total amount of seeds from different generations that were shipped to Korea.

Trial	Total (kg)
F_6 lines	40.9
F_6 SSD bulk population	3.6
F_3 bulk population	30.3
Seed multiplication	8.0
Total	82.8

Survey of Soybean Production, Problems, and Needs in the Tropics

A soybean survey questionnaire was sent to 158 people in various countries in the tropics. Fifty participants from 37 countries returned the questionnaire, of which 21 were from Asia, 12 from Africa, 13 from Latin America, and four from the Pacific Islands and Australia. The data are now being analyzed.

Soybean Entomology

Preliminary Screening of Soybean Germplasm for Resistance to Beanfly (mainly *Ophiomyia phaseoli*) in Indonesia

Introduction

The agromyzid beanfly pest complex that infest soybean in Taiwan and the rest of the tropical and subtropical Asia differs from the one that infests soybean in Indonesia. In Indonesia *Ophiomyia phaseoli* takes a heavy toll on soybean, while in the rest of Asia, *Melanagromyza sojae* is the major soybean problem. While *M. sojae* is a pith feeder, the *O. phaseoli* feeds on the cortex just underneath the epidermis. It rarely feeds on pith. As a result of the difference in feeding habit, accessions that are resistant to *M. sojae* are not resistant to *O. phaseoli*. Since beanfly damage is more severe in Indonesia, a cooperative research project was initiated to screen AVRDC's soybean germplasm for *O. phaseoli* resistance in the P. T. Patra Tani soybean fields near Palembang, South Sumatra.

Materials and Methods

During November to late December two lots of 500 accessions each were shipped to Indonesia. The first lot was planted in late December 1983 and the second, in early January 1984. Each entry was planted in a single 5 m long row with a distance of 75 cm between two adjacent rows. Four weeks after germination, the number of dead and surviving soybean plants was recorded. The percentage of plant mortality was analyzed by a statistical method based on mean and standard deviation to classify accessions into the following categories: high resistance (HR), moderate resistance (MR), low resistance (LR), susceptible (S), and highly susceptible (HS).

Results

The first group of 500 accessions were all killed by beanfly infestation. In the second group of 500 accessions planted, 308 had 10 or more living or dead plants at 28 to 30 days after germination. Only these accessions were evaluated. The relative resistance classification of these accessions is summarized in Table 1. The mean percentage of mortality for 308 accessions was 69% with a range of 7.7 to 100%.

Table 1. Resistance rating of soybean accessions screened for *O. phaseoli* resistance at Palembang, Indonesia.[z]

Resistance Category	Plant Mortality Range	No. of Accessions
HR	less than 31%	12[y]
MR	32 to 50%	42
LR	51 to 68	77
S	69 to 100	177

[z]Planting date January 6, evaluation date February 2, 1984. [y]AVRDC Acc. Nos. G523, G645, G647, G722, G770, G785, G790, G806, G890, G892, G893, and G958

All these accessions, however, showed susceptibility to *M. sojae* at AVRDC. The 12 HR accessions will be screened once again in Indonesia to confirm the resistance. Another 1000 entries during 1985 will also be screened in order to obtain better sources of resistance.

Preliminary Screening of Additional Soybean Accessions for Resistance to Beanfly (mainly *M. sojae*) at AVRDC

Introduction

Up until autumn 1982 at AVRDC, over 9,000 accessions, practically all AVRDC soybean germplasm, were screened for resistance to beanflies, mainly *M. sojae*. Only four *Glycine soja* accessions showed moderate to high levels of resistance to *M. sojae*. From 1982 to 1984 additional germplasm was received which were screened along with those that could not be screened in the past due to inadequate seed supply.

Materials and Methods

Seeds of each accession were planted in a single, 5 m long row on the top of 75 cm wide beds. The crop was grown according to customary cultural practices, except that no insecticide was applied. Six weeks after planting, a 10-plant sample was uprooted from each, the stems were cut open, and the number of beanfly larvae and pupae found within was recorded. Also recorded was the number of plants with clearly visible damage by the beanflies. The insect number per 10 plants and plant damage percentage were statistically analyzed to classify accessions into relative resistance categories.

Results

The classification of the 344 accessions screened for beanfly resistance is shown in Table 2. All accessions were damaged to a lesser or greater degree by beanflies. The number of beanfly larvae + pupae per 10 plants ranged from 0 to 26 and the percentage of plants damaged, from 20 to 100%. The 12 accessions that fell under the HR category by number of larvae + pupae/10 plants also belong to this category based on percentage of plants damaged. These 12 accessions all belong to the wild soybean species. They have small viny stems which lodge easily. Besides, the resistance in these accessions seems to be due to its small pith diameter which cannot easily accommodate a beanfly larva. Therefore, these materials may not be used in breeding for *M. sojae* resistance in soybean. This breeding program had now shifted to the search for beanfly-tolerant cultivars.

Table 2. Classification of selected soybean accessions into various resistance categories.[z]

Resistance Category	No. Accessions Based on	
	larvae + pupae /10 plants	damaged plants (%)
HR	12	26
MR	39	9
LR	110	6
S	172	303
HS	11	0

[z]Planted Sept. 21, evaluated Nov. 8, 1984

Third Screening of Selected Soybean Accessions for Resistance to Beanflies

Introduction

In autumn 1982, 2,169 accessions were screened for resistance to beanflies, mainly *Melanagromyza sojae*, at AVRDC. A total of 217 least affected entries was selected and tested for resistance to beanfly, mainly *Ophiomyia phaseoli*, at Palembang, Indonesia in autumn 1983. Fourteen less damaged accessions (average plant mortality of less than 70%) were classified as highly resistant. Thirteen of these accessions were screened with two susceptible checks for resistance to beanfly at AVRDC in autumn 1984 for the third time.

Materials and Methods

A 0.05 ha field was rototilled, applied with basal fertilizers, and worked into 75 cm wide beds. The beds were divided into 5 m long plots. The seeds of each of 15 accessions included in this test were sown as a single row on the top of each bed. Each accession was planted in three randomly arranged beds. The crop was raised according to customary cultural practices, except that no insecticide was applied. At five weeks after germination, a 10-plant sample was taken from each plot. Each plant was cut open and the number of beanfly larvae and pupae found inside was recorded. The number of plants with visible beanfly damage in each sample was also recorded. The insect count and plant damage percentage were analyzed by Duncan's Multiple Range Test.

Results

The results of beanfly infestation of these accessions are presented in Table 3. The 13 accessions belonging to species *Glycine javanica* and *G. soja* had significantly less insects than two *G. max* susceptible checks. Some of the resistant accessions had beanfly damage, but we could not find any larvae, pupae, or empty pupal cases. This indicated that the insect attacked the plants but perished before the pupal stage.

Table 3. Beanfly infestation of selected soybean accessions during the third screening for resistance at AVRDC.[z]

Accession No.	Identification	No.of Beanfly Larvae + Pupae/ 20 Plants	Damaged Plants (%)
G5157	*Glycine javanica*	0.0c	50bcd
G5158	"	0.0c	21d
G9062	*G. soja*	0.0c	86ab
G3112	"	0.7c	59abcd
G3101	"	0.7c	73abc
G9078	"	1.3c	70abc
G9065	"	1.3c	66abc
G9084	"	1.3c	60abcd
G9286	"	1.7c	73abc
G3085	"	1.7c	39cd
G9091	"	1.7c	75abc
G9162	"	1.7c	86ab
G9126	"	2.3	64abc
G2029	*G. max*	29.0	100a
G6	"	42.7	100a

[z]Mainly *Melanagromyza sojae*, planting date: Sept. 21, evaluation date: Oct. 26, 1984. Means having the same letter in each column are not significantly different at the 5% level by Duncan's multiple range test

All 13 resistant accessions have distinctly thin stems and these plants lodge easily. The resistance appears to be due to the small stem which is too woody for feeding and a pith tissue which is too narrow for penetration. As a result, these plants are less damaged. Our past work with beanfly-resistant *G. soja* indicated that the resistance is associated with the thin stem which, from an agronomic point of view, is distinctly an undesirable character. Therefore, the use of newly found accessions resistant to *G. javanica* and *G. soja* is rather limited.

Conclusion

Two *Glycine javanica* and 11 *G.soja* accessions show moderate to high levels of resistance to a beanfly species, *Melanagromyza sojae*.

Beanfly Infestation and Soybean Yield under Natural Autumn and Extended Photoperiods

Introduction

Over the past years, it has been observed that beanfly infestation and damage in soybean are always greater in autumn than in spring. For many years, the rainfall, average temperatures, and relative humidity of these two seasons have not been much different.

One important difference between these two seasons, however, is the length of photoperiod. In autumn, photoperiod decreases as the plants grow; in spring, it increases. Soybean is a photoperiod-sensitive crop, and since photoperiod affects the physiology and growth of the plants, it may have some influence on beanfly damage. In this experiment, therefore, the role of photoperiod in beanfly infestation and yield reduction was studied.

Materials and Methods

A 0.05 ha piece of land was rototilled and worked into 1 m wide beds across the length of the field. The land was divided into two sections, each comprising eight plots, each plot measuring 3 m wide and 3.3 m long (10 sq m). Seeds of cultivar KS9 were sown in two rows on each bed in each plot. The distance was 10 cm between two adjacent hills in each row. In one section comprising eight plots, electric lights were installed at the junction of a 3 m × 3 m grid. The bulbs were placed 160 cm above the soil surface. Soon after germination the photoperiod in this section was increased to a total of 13 hr and 10 min., the longest photoperiod to which plants are exposed in the spring season. This was done by switching the lights on at 4 p.m. and shutting them off when total photoperiod (natural + artificial) reached 13 hr and 10 min. The other section of the field was left undisturbed. A tinplate fence was erected between the two sections to prevent light transmission to the other side.

Four plots in each section were treated with Omethoate 50EC at the rate of 0.5 kg a.i./ha 3, 7, 10, 14, 21, 28, and 35 days after germination.

At five weeks after germination, a 30-plant sample was taken from each plot; and each plant was dissected to record the number of beanfly larvae and pupae, as well as visible beanfly damage. The number of beanfly larvae and pupae per 30 plants, as well as the percentage of damaged plants were later calculated.

At the R3 stage, a further 10-plant sample was taken from each plot and the number of leaflets, as well as leaf area/plant were recorded. Also recorded were fresh and dry weights of leaflets, stems, and roots. At harvest seed yield was recorded.

Results

The results of beanfly infestation, plant growth, and seed yield of plants grown under natural and extended photoperiod are shown in Table 4. The number of larvae + pupae per

30 plants grown under extended photoperiod was significantly less than in the control plants. There was, however, no significant difference when percentage of damaged plants under both photoperiods were compared. In both photoperiods insecticide application reduced beanfly infestation significantly.

Table 4. Beanfly infestation, plant growth, and yield response of soybean under normal and extended photoperiods.

	Natural Photoperiod			13.5-hr Photoperiod		
	without insecticide	with insecticide[z]	level of significance[y]	without insecticide	with insecticide	level of significance
No.beanfly P + L /30 plants	60.5	2.0	**	43.0	2.3	**
Percentage of damaged plants	98.5	12.5	**	93.5	15.8	**
Leaflet no./plant	30.6	32.6	NS	47.5	47.0	NS
Leaf area (cm^2) /plant	758.9	1003.3	**	1691.7	1879.5	NS
Fresh wt (g) of -						
roots	1.4	1.5	NS	2.0	2.5	NS
stems	19.3	27.3	**	39.6	48.0	NS
leaves	10.7	13.0	*	21.0	20.3	NS
Dry wt (g) of -						
roots	0.5	0.6	NS	0.9	1.1	NS
stems	4.5	6.2	**	8.9	11.3	NS
leaves	3.2	4.1	NS	5.6	6.1	NS
Yield (kg)/10 m^2	1.9	2.1	*	2.3	2.2	NS

[z]Omethoate sprayed at 0.5 kg a.i./ha, 3, 7, 14, 21, 28, and 35 days after germination. [y]Indicates the difference between insecticide-treated and untreated plots. NS = not significant; * = significant at the 5% level, and ** = significant at the 1% level.

Although there was not much difference in leaflet numbers of plants grown under two photoperiods, the total leaf area under the extended photoperiod was significantly greater. Insecticide treatment significantly increased leaf area under natural photoperiod, but under the extended photoperiod there was no difference. This increased leaf area influenced plant growth as reflected in fresh and dry weights of the stems. Differences in fresh and dry weight accumulation between insecticide-treated and untreated plants were highly significant under natural photoperiod and were not significant under the extended photoperiod. Similarly, insecticide treatment significantly increased seed yield under natural photoperiod, but such treatment had no significant effect under the extended photoperiod.

There was no difference between the temperatures under normal and extended photoperiods.

Yield reduction due to beanfly infestation of autumn soybean thus appeared to be the result of shorter photoperiod. The plant did not have enough source to compensate for the beanfly damage. Under the extended photoperiod, the plant put up extra vegetative growth and matured late; thus, it was able to make up for beanfly damage. The difference in yield loss due to beanflies in the autumn and spring soybean seemed to be caused by the difference in photoperiod.

Conclusion

The significant yield loss of soybean in autumn due to beanfly infestation compared with no yield loss in spring seemed to be related to the difference in the length of photoperiods between the two seasons.

Resistance Mechanism of Selected Soybean Accessions to *Porthesia taiwana*

Introduction

Three soybean accessions, PI171451, PI227687, and PI229358, were reported to be resistant to two soybean foliage feeders; Mexican bean beetle, *Epilachna varvivestis*, and *Heliothis armigera* in the United States. At AVRDC in 1982, these accessions showed high level of resistance to beet armyworm, *Spodoptera exigua*. Further studies here indicated that these accessions have an antibiotic effect on beet armyworm. Since *Porthesia taiwana*, a polyphagous insect also infests soybean, at times seriously in the spring season, a preliminary study was made of these accessions' antibiosis on this insect pest in 1983. Based on these preliminary results additional characteristics were studied to confirm this antibiosis.

Materials and Methods

The three PI accessions and cultivar TK5 (susceptible check) were grown in the field away from areas of frequent insecticide use. Sowing was done at monthly intervals to assure a supply of foliage for the insect-feeding study.

Two fresh leaflets of each accession were confined in a petri dish and five first-instar *P. taiwana* larvae were released in each of eight dishes. The petri dishes were maintained at 25°C and 65% RH. The leaves were replaced at every one-to three-day intervals. At each replacement, the leaf area was measured on a Licor area meter before giving the leaves to the insect and again after removing the consumed leaves prior to the next replacement. The amount of leaf area consumed was deduced by substraction.

The number of dead larvae were recorded every day. At pupation the total larval period and pupal weights were recorded. The pupae were confined in a cage containing soybean plants and observed daily for adult emergence. The number of adults that emerged were recorded, and the adults maintained in the same cage until all died. The number of eggs laid were recorded and the number of eggs per female were calculated. Also recorded was the longevity of each adult.

Results

P. taiwana larvae reared on PI accessions had greater mortality than those fed susceptible TK5 leaves (Fig. 1). Among the PI entries more larvae died on PI171451 and PI227687 than on PI229358. Insect mortality on PI229358 was only marginally greater than on TK5. The insects suffered greater mortality in the final instar just before pupation. This could be due to the toxic properties or reduced nutritional quality of the PI accessions.

It is interesting to note that, whereas PI171451 exhibited stronger antibiosis than the other two PI accessions to *P. taiwana*, in our 1982 study it showed a weaker antibiosis to *S. exigua*. The larvae consumed significantly less PI171451 and PI227687 foliage than the other entries (Table 5). The larval periods of insects fed on PI171451 and PI227687 were significantly longer than those of larvae fed on the other two entries.

The pupation rate of larvae fed PI entries were shorter than that of insects fed TK5. Among the PI entries, PI171451 had the least number of insects reaching the pupal stage. Although there was no significant difference in pupal weights, the pupae from larvae reared on PI171451 were lighter than those on other entries. Pupal period did not differ significantly among accessions. The rate of adult emergence and adult longevity did not differ, but the number of eggs laid per female was much less in insects reared on PI171451 than in those reared on other accessions (Table 6).

Conclusion

Foliage of PI171451, PI227687, and PI229358 showed an antibiosis to *P. taiwana*, with PI171451 exhibiting the greatest level.

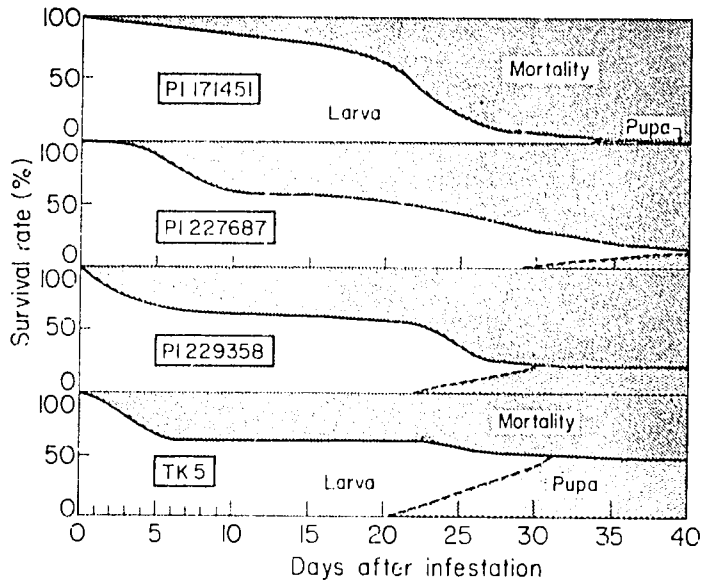


Fig. 1. Growth and development of *Porthesia taiwana* on various soybean accessions.

Table 5. Leaf consumption and certain biological parameters of *P. taiwana* reared on foliage of selected soybean accessions.[z]

Accession	Total Leaf Consumption /Larva (cm^2)	Larval Duration (days)	Pupation Rate (%)	Pupal Weight (mg)	Pupal Period (days)
PI171451	32.59bc	37.0a	2.5c	41.5	9.0
PI227687	29.39c	36.0a	20.0bc	52.5	10.3
PI229358	48.86b	26.2b	32.5b	54.7	10.0
TK5	73.43a	25.9b	57.5a	58.6	10.0

[z]Data are means of eight replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Table 6. Certain biological parameters of *P. taiwana* adults from larvae reared on foliage of selected soybean accessions.

Accession	Adult Emergence (%)	Adult Longevity (days)	No. Eggs per Female
PI171451	100	5.0	60
PI227687	91.8	5.3	90
PI229358	95.0	4.5	109
TK5	96.0	5.7	100

Antibiosis of Selected Soybean Accessions to Scarabid Beetles

Introduction

Two species of scarabid beetles, *Anomala cupripes*, and *A. expansa*, infest soybean and other crops, mostly legumes, every year in spring. The adults of these species feed on soybean

leaves and, if control measures are not adapted, cause serious defoliation. Since three soybean accessions, PI171451, PI227687, and PI229358, have shown various levels of antibiosis to three other defoliators, namely *Spodoptera exigua*, *Porthesia taiwana*, and *Orgyia* sp., a preliminary trial was conducted in 1983 which indicated that *A. cupripes* consumes significantly less PI229358 foliage than the two PI entries or TK5 (susceptible check). High temperatures during foliage feeding reduced consumption much more drastically in PI entries than in TK5. In 1984, we conducted another study to confirm this antibiosis to scarabid beetles.

Materials and Methods

The above three PI accessions and cultivar TK5 (susceptible check) were grown in the field away from areas of frequent insecticide use. Sowing was done at monthly intervals to assure a supply of foliage for the insect-feeding study.

A. cupripes adults were collected from the light trap in April when they started appearing for the first time. They were maintained on soybean leaves in a nylon screen cage (45 × 45 × 40 cm) for one to two days before initiation of the experiment. The insect longevity and feeding study was done at 25° and 30°C.

Several fresh leaflets of each accession were placed in a petri dish (14.5 cm in diameter, 2.5 cm high). Three to four beetles were released in each of the 12 petri dishes maintained at 25°C, and one beetle in each of the 20 petri dishes exposed to 30°C. The leaves were replaced at one-to three-day intervals. At each replacement, the leaf area was measured on a Licor area meter before feeding the leaves to the insects and again after removing the consumed leaves prior to the next leaf replacement. The amount of leaf area consumed was deduced by substraction. The number of dead beetles were recorded every day to calculate longevity.

Results

The results of insect longevity, total foliage consumption, and daily foliage consumption at 25° and 30°C are presented in Table 7. The insects feeding on PI229358 leaves had the lowest longevity and consumed significantly less foliage than those on susceptible check cultivar TK5 and PI171451. There was no difference either in longevity or foliage consumption of PI171451 and TK5. Insects feeding on PI227687 had significantly lower longevity than those feeding on TK5 or PI171451, but the former's daily foliage consumption did not differ significantly from that of the latter two entries. As a result of reduced longevity on PI229358, total and daily leaf consumption were significantly less.

Insects maintained at 30°C on all accessions had reduced longevity and foliage consumption. PI229358, therefore, is antibiotic to *A. cupripes* and it represents a source of resistance in breeding. It is interesting to note that PI171451 had a stronger antibiosis to the lepidopterous defoliator *Porthesia taiwana*, but it is susceptible to coleopteran *A. cupripes*. PI227687 has shown stronger levels of antibiosis to *Spodoptera litura*. To breed for resistance to foliage-feeding insects, therefore, it will be necessary to combine the resistance of all three accessions.

Table 7. Longevity and foliage consumption by *A. cupripes* fed on leaves of four soybean accessions.[z]

Accession	Longevity (days)		Total Leaf Area (cm^2) Consumed/Insect		Leaf Area (cm^2) Consumed/Day	
	25°C	30°C	25°C	30°C	25°C	30°C
PI171451	39.9a	8.3a	547a	64.5a	13.0a	6.6a
PI227687	19.4b	6.0bc	236c	30.8bc	9.6b	4.6b
PI229358	9.4c	5.1c	65d	9.8c	4.4c	2.1c
TK5	36.7a	7.8ab	374b	50.4bc	9.5b	5.7ab

[z]Data for 25°C are the means of 12 replicates and for 30°C, the means of 20 replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Conclusion

Soybean accession PI229358 showed strong antibiosis to a scarabid beetle, *A. cupripes*. The insect reared on foliage of this accession had significantly reduced longevity and consumed significantly less foliage than the insects reared on TK5 or PI171451.

Screening of Soybean Accessions for Resistance to Lima Bean Pod Borer

Introduction

Lima bean pod borer, *Etiella zinckenella*, is a serious pest of soybean in tropical and subtropical Asia. Its damage is especially severe throughout the year in Indonesia. Seven soybean accessions found consistently resistant to this insect at AVRDC were, however, susceptible in Indonesia. Investigations showed that this resistance at AVRDC resulted mainly from the fact that these accessions were late-maturing, and so escaped the insect peak population which coincided with the maturity of susceptible accessions. Fresh screening for resistance irrespective of season or insect population pressure was, therefore, started. This time planting was done in September and in October and a large number of *E. zinckenella* pupae were released at regular intervals to augment natural pod borer population.

Materials and Methods

A 0.75 ha piece of land away from areas of frequent insecticide use was rototilled, applied with basal fertilizer, and worked into 75 cm wide beds. These beds were further divided into 5 m long plots. Seeds from each of the 1,000 soybean accessions were sown in a single 5 m long row plot on the top of each bed. We planted the crop twice on identical plot size and design on September 11 and October 11, 1983. Routine cultural practices were used, except that no insecticide was applied.

Beginning with the flowering of the earliest flowering accessions and at about 10-day intervals thereafter, we released a large number of laboratory-reared *E. zinckenella* pupae. The pupae were placed at regular distances throughout the field. At harvest time which varied for different accessions, all plants in each plot were harvested and their pods examined for lima bean pod borer damage. The number of damaged and healthy pods was recorded, and the percentage of damaged pods was calculated on a statistical method based on mean and standard deviation (sd).

This method enabled us to classify the accessions into various resistance categories. Accessions considered as highly resistant (HR) had pod-damage percentage less than mean − 2sd; those considered moderately resistant had pod-damage percentage between mean − 2sd and mean − 1sd; those that showed low resistance (LR) had pod-damage percentage between mean and mean − 1sd; the susceptible (S) accessions had pod-damage percentage between mean and mean + 2sd; and the highly susceptible (HS) accessions showed pod-damage greater than mean + 2sd.

Results

The results of both screenings are summarized in Table 8. Pod-damage varied from 0 to 93% in the first, and 0 to 37% in the second planting. In the first planting only one accession was free of damage and fell under the HR category; however, this same accession had 7.5% pod-damage in the second and was classified under the LR category. Although a large number of accessions, 126 in the first and 108 in the second, belonged to the MR category, only four (G98, G111, G584, and G909) were MR in both plantings. These accessions thus had the least damage irrespective of planting date or lima bean pod borer population pressure. These

accessions will be studied in 1985 to ascertain their resistance mechanism before testing them elsewhere in Asia prior to their use in our pod borer resistance breeding program.

Conclusion

Four soybean accessions; G98, G111, G584 and G909, showed moderate resistance to lima bean pod borer in two screenings at AVRDC. These accessions will be studied further for their mechanism of resistance to lima bean pod borer.

Table 8. Distribution of soybean accessions into various resistance categories based on lima bean pod borer infestation.

Resistance Category	No. of Accessions	
	first screening[z]	second screening[y]
HR	1	0
MR	126	108
LR	444	468
S	370	362
HS	48	40
Total	989	978
Mean damage percentage	29.47	7.89
SD damage percentage	±14.66	±4.91
Range damage percentage	0 to 93	0 to 37

[z]Sowing date: Sept. 8, 1983; harvest date: Nov. 12, to Dec. 14 1983. [y]Sowing date: Oct. 11; harvest date: Jan. 3 to 20, 1983.

Soybean Pathology

Preliminary Rust Tolerance Trials

Introduction

Significant variations in relative yielding ability of soybean cultivars under rust stress (tolerance) were known to exist. In order to evaluate and select soybean breeding lines with improved rust tolerance, high-yielding ability, and early maturity, a series of rust-tolerance trials were established.

Materials and Methods

The preliminary rust-tolerance trials (PRTTs) are usually non-replicated experiments unprotected by fungicide. Five PRTTs were conducted in spring 1984. The numbers of test families and lines in each trial are listed in Table 1. All families and lines had been previously evaluated and selected for potential rust resistance and/or tolerance. All PRTTs were planted on March 1 with plant density equivalent to 200,000 plants/ha and plot size of 2 × 3 m.

The check cultivars were G38, AGS129, KS8 (yield check), and AGS181 (highly tolerant check). All plots were inoculatd with a rust uredospore suspension on April 13 and 24. Data on yield per plot and 100-seed weight were collected at harvest and converted to 13% moisture content before evaluation. All other AVRDC cultural practices were followed.

Results

A total of 67 selections, 30 as bulk harvested lines and 37 as single plants, were made in PRTTs in the spring (Table 1). In PRTT-I, 16 F10 SRE-B lines and nine AVRDC accessions were identified as potentially rust-tolerant. Six of these were potentially better yielding than G38 (moderately tolerant check) and two were better yielding than AGS181 (highly tolerant

Table 1. Number of families tested and number of families and lines selected for potential levels of tolerance in the five preliminary rust tolerance trials in spring, 1984.

PRTT	Generation	Cross designatiog	Families or Lines Evaluated	With Single Plant Selection	No. of Plants Selected	No. of Bulk Harvested Lines for Advance
I	F10	SRE-B	66	8	18	25
	–	Accession				
	–	PI				
II	F7	SRE-D	53	10	17	5
		GC				
III	F9	SRE-C	2	0	0	0
IV	–	R[z]	23	1	1	0
V	F8	SRE-C	7	1	1	0

[z]Lines received from Dr. D. E. Byth, Univ. of Queensland, Australia.

check)(Table 2). In PRTT-II, only five F7 GC lines were considered to be better yielding than AGS181 (Table 3). The 100-seed weight of these five lines were also considerably higher than that of the check cultivars. No lines in PRTT-III, IV, or V were selected.

Since some high-yielding families were segregating for plant type, 18 single-plant selections from eight PRTT-I families, 17 from 10 PRTT-II families, and one selection from one family in each of PRTT-IV and PRTT-V were made in the spring (Table 1).

Conclusion

A number of potentially rust-tolerant, high-yielding and early-maturing lines were identified in the experiment, and will be re-evaluated in the future.

Table 2. High-yielding, potentially tolerant lines in the preliminary rust tolerance trial I, spring 1984.[z]

Line Designation	Days to Maturity	Yield[y](g/3m^2)	100-Seed Wt[y](g)
SRE-B-15-0-0-0-3-BK-1e-BKt-BK-7	96	771.4	13.6
SRE-B-15-0-3-2-1-BK-2e-BKt-BK-1	97	737.3	17.9
SRE-B-15-0-0-0-9-BK-1e-BKt-BK-2	102	683.1	12.6
SRE-B-15-0-0-0-3-BK-1e-BKt-BK-1	96	678.2	15.6
SRE-B-15-0-0-0-9-BK-1e-BKt-BK-1	102	676.7	13.4
SRE-B-15-0-0-0-9-BK-1e-BKt-BK-4	102	670.4	13.3
AGS181 (SRE-Z-11A)	92	725.7	16.4
G38 (Shih-Shih)	92	634.0	12.5
KS8	102	576.2	13.7
AGS129	102	364.0	8.0

[z]Date planted: March 1, 1984; plot size: 2×3 m; no. of lines evaluated: 66. [y]At 13% moisture content.

Table 3. High-yielding, potentially tolerant lines in the preliminary rust tolerance trial II, spring 1984.[z]

Line Designation	Days to Maturity	Yield[y](g/3m^2)	100-Seed Wt[y](g)
GC00031-BK-BKe-3e-1-2-1	96	703.0	18.5
GC00031-BK-BKe-2e-2-1-2	102	608.5	17.4
GC00031-BK-BKi-9e-1-3-1	98	587.7	17.4
GC00031-BK-BKi-11e-2-1-4	102	577.6	18.5
GC00031-BK-BKi-11e-1-1-3	102	568.5	17.0
AGS181 (SRE-Z-11A)	92	673.6	15.4
G38 (Shih-Shih)	92	524.6	14.6
AGS129	102	423.1	7.8

[z]Date planted: March 1, 1984, plot size: 2×3 m; no. of lines evaluated: 53 [y]At 13% moisture content.

Intermediate Soybean Rust Tolerance Trial, Spring 1984

Introduction

Previous results have shown that significant variations in relative yielding ability exist among soybean cultivars under stress from a rust epidemic. Therefore, a series of rust tolerance trials, preliminary (PRTT), intermediate (IRTT), and advanced (ARTT), have been established to evaluate and select soybean lines with improved rust tolerance, high yield, and early maturity. Selected lines from IRTT are advanced to the ARTT.

Materials and Methods

Three intermediate rust tolerance trials, IRTT-I, IRTT-II, and IRTT-III, were conducted in spring 1984. Used in these three experiments were 45, 25, and 37 advanced lines with five

check cultivars. These lines were previously selected based on uniform morphology and yield ability under severe rust stress. Check cultivars were G38, AGS129, KS8, AGS181, and TN4. Plot size for each line or cultivar was 2×3 m (3^2 harvested area), and plant density was equivalent to 200,000 plants/ha.

A split-plot design with two replications in IRTT-I and three replications in IRTT-II and IRTT-III was used. Main plots were fungicide and nonfungicide treatments. Subplots were advanced lines and check cultivars. All three experiments were planted on February 29, 1984. The nonfungicide plots were inoculated with rust 34 and 48 days later. Dithane M-45 was sprayed on fungicide-protected plots every two weeks. AVRDC cultural practices were followed.

Data collected included yield, 100-seed weight, and days to maturity. Yield data were converted to 13% moisture content before evaluation. Yield loss was expressed as percentage of fungicide-protected yield.

Sixteen test lines were included in IRTT-I, ten in IRTT-II, and nine in IRTT-III. These lines were previously selected as potentially tolerant to rust, as well as potentially high-yielding and resistant to lodging in the rainy season.

Results

In IRTT-I, ten fungicide-protected lines had yields significantly higher than G-38, and two lines had yields not significantly different from TN4 the highest-yielding check (Table 4). Four lines in the unprotected treatment had levels of tolerance and yield similar to that

Table 4. Yield and yield loss percentage of advanced breeding lines in the intermediate rust tolerance trial-I grown under fungicide and nonfungicide treatments during a soybean rust epidemic in spring 1984, AVRDC.

Cultivar	Yield (t/ha)[z]		Yield Loss (%)
	fungicide-protected	unprotected	
SRE-D-11-3-BKe-1e-1-1-BK	3.03 +[y]	1.64[x]	45.0
SRE-D-11-3-BKe-1e-5-1-BK	3.05 +	1.65	45.8
SRE-D-11-3-BKe-1e-9-1-BK	3.25 +	1.44 –	55.7
SRE-D-11-3-BKe-1e-9-5-BK	3.41 +	1.47 –	56.9
SRE-D-11-3-BKe-1e-10-1-BK	3.14 +	1.65	47.4
SRE-D-11-3-BKe-1e-10-2-BK	3.57 +	1.75	51.0
SRE-D-18-0-BKe-1e-1-2-BK	2.77	1.66	39.9
SRE-D-18-0-BKe-3e-1-4-BK	2.56	1.95 +	23.5
SRE-D-18-0-Bke-4e-1-3-BK	2.63	1.86	29.1
SRE-D-14-0-BKi-1e-1-1-BK	3.27 +	1.71	47.5
SRE-D-18-0-BKi-1e-2-2-BK	2.74	1.78	35.2
SRE-D-18-0-BKi-1e-3-3-BK	2.89 +	1.24 –	57.2
SRE-D-14-0-BKI-6e-1-2-BK	3.21 +	1.74	45.8
SRE-D-14-0-BKI-6e-3-5-BK	2.64	1.78	32.6
SRE-D-14-0-BKI-6e-5-2-BK	2.50	1.79	28.4
SRE-D-11-3-BKI-7i-2-1-BK	3.00 +	1.49 –	50.2
G38 (Shih-Shih)[w]	2.66	1.37 –	48.7
AGS129[w]	3.14 +	1.27 –	59.6
KS8[w]	3.40 +	1.33 –	60.9
AGS181 (SRE-Z-11A)[w]	2.34 –	1.72	26.6
TN4[w]	3.55 +	0.90 –	73.0
LSD .05	0.223		

[z]Plot size for each cultivar is 3×2 m (harvested area = 3 m^2), and plant density is equivalent to 200,000 plants/ha. [y]Significantly different ($P < 0.05$) in yield from check cultivars G38: + = greater than check; – = less than check. [x]Significantly different ($P < 0.05$) from tolerant check cultivar AGS181: + = greater than check; – = less than check. [w]Check cultivars.

of the highly tolerant check (AGS181). One line, D-18-0-BKe-3e-1-4-BK, showed a level of tolerance (as indicated by percentage of yield loss) lower than the highly tolerant check.

In IRTT-II, none of the test lines yielded better than G38 in the fungicide-protected plots (Table 5). However, nine of the 10 test lines yielded better than the highest-yielding check in the unprotected plots; and seven of these lines had higher levels of tolerance than the highly tolerant check. One line had the lowest yield loss of only 10.7% compared with the rest, including the highly tolerant checks. Two unprotected lines yielded more than 2 t/ha compared with the rest, including the high-yielding check.

In IRTT-III, one line yielded better than G38 and three had similar yields to the check in the fungicide-protected treatments (Table 6). All the test lines yielded at least as well as the highly tolerant check (AGS 181), and six of the nine lines yielded significantly better. Two untreated lines yielded more than 2 t/ha compared with 1.23 t/ha for AGS129.

Conclusion

In this spring trial, a number of highly tolerant lines, some of which are more tolerant than the highly tolerant check, have been identified. Some potentially high-yielding lines with moderate to high levels of rust tolerance have also been disclosed. The best lines in the IRTT will be selected and advanced to the ARTT when the fall 1984 trials are completed.

Advanced Soybean Rust Tolerance Trial, Spring 1984

Introduction

A series of rust tolerance trials, preliminary (PRTT), intermediate (IRTT), and advanced (ARTT), have been established to evaluate and select lines with improved rust tolerance, high yield, and early maturity. Selected lines from the IRTT are advanced to the ARTT from which the best lines will be tested in selected countries with serious soybean rust problems.

Materials and Methods

Seven advanced lines previously selected for rust tolerance and high yield potential were planted in 3 × 6 m (2 × 5 m harvested area) plots at a plant density equivalent to 400,000 plants/ha. The check cultivars were G38 (moderately tolerant), AGS129 (high-yielding), and AGS181 (highly tolerant). A split-plot design with four replications was used. Main plots were fungicide and nonfungicide treatments. Subplots were the advanced lines and check cultivars. All lines were planted on February 1984, and the nonfungicide plots were inoculated with rust 36 and 53 days later. The fungicide Dithane M-45 was sprayed every two weeks. AVRDC cultural practices were followed.

Data collected were on yield, 100-seed weight, days to maturity, defoliation, and percentage of rust severity. Yield data were converted to 13% moisture content before evaluation. Yield loss was expressed as percentage of fungicide-protected yield. Rust severity and defoliation were estimated in percentage. The rate of rust development was the regression coefficient of the correlation between logit of total rust-affected foliage (rust-affected foliage + defoliation) and relative life time (DAP × 100/days to R8).

Results

All test cultivars, except GC60031-2-7-6-6 and G2120-97RR-1, possessed levels of tolerance (based on yield loss percentage) similar to the highly tolerant check (AGS181) and were higher yielding than AGS181 in the nonfungicide treatment. However, all fungicide-protected cultivars, except GC60087-7-9-6-11-46, yielded less than G38 (Table 7). As in the past, only small differences in the rates of rust development were observed (Table 8).

Table 5. Yield and yield loss percentage of advanced breeding lines in the intermediate rust tolerance trial-II grown under fungicide and nonfungicide treatments during a soybean rust epidemic in spring 1984, AVRDC.

Cultivar	Yield (t/ha)[z]		Yield Loss (%)
	fungicide-protected	unprotected	
SRE-C-22-0-BK-BKe-BKe-2e-1-2-BK	2.24 –[y]	1.89 +[x]	15.7
SRE-C-22-0-BK-BKe-BKe-2e-1-4-BK	2.47 –	1.98 +	20.0
SRE-C-22-0-BK-BKe-BKe-2e-2-3-BK	2.36 –	1.81 +	23.5
SRE-C-41-0-BK-BKe-BKe-3e-2-4-BK	2.52 –	1.64	34.9
SRE-C-33-0-BK-BKe-BKi-2e-1-2-BK	2.38 –	1.74 +	27.2
SRE-C-56-1-BK-BKe-BKi-2e-2-3-BK	2.58 –	2.06 +	20.1
SRE-C-56-1-BK-BKe-BKi-2e-2-4-BK	2.47 –	1.90 +	22.8
SRE-C-57-0-BK-BKe-BKi-3e-2-3-BK	2.30 –	1.89 +	18.1
SRE-C-22-0-BK-BKe-BKI-5e-1-2-BK	2.48 –	1.84 +	26.0
SRE-C-56-1-BK-BKe-BKI-1i-1-1-BK	2.38 –	2.12 +	10.7
G38[w]	2.97	1.32 –	55.6
AGS129[w]	3.15 +	1.20 –	61.9
KS8[w]	3.27 +	1.36 –	58.5
AGS181[w]	2.21 –	1.58	28.7
TN4[w]	3.10 +	0.91 –	70.5
LSD .05	0.118		

[z]Plot size for each cultivar is 3 × 2 m, and plant density is equivalent to 200,000 plant/ha. [y]Significantly different (P 0.05) in yield from check cultivar G38. + = greater than check, – = less than check. [x] Significantly different (P 0.05) from tolerant check cultivar AGS181. + = greater than check; – = less than check. [w]Check cultivars.

Table 6. Yield and yield loss percentage of advanced breeding line in the intermediate rust tolerance trial-III grown under fungicide and nonfungicide treatments during a soybean rust epidemic in spring 1984, AVRDC.

Cultivar	Yield (t/ha)[z]		Yield Loss (%)
	fungicide-protected	unprotected	
SRE-B-15-0-0-0-9-BK-1e-BKt-1-BK	2.80[y]	1.96 +[x]	29.9
SRE-B-15-0-0-0-9-BK-1e-BKt-3-BK	2.88 +	2.14 +	25.8
SRE-B-15-0-3-2-1-BK-2e-BKt-1-BK	2.23 –	1.96 +	11.8
SRE-B-15-0-3-2-1-BK-2e-BKt-2-BK	2.12 –	1.76	16.9
SRE-B-15-0-3-2-1-BK-2e-BKt-4-BK	2.20 –	1.87 +	14.9
SRE-B-15-0-0-0-9-BK-1e-BKt-6-BK	2.69	1.74	35.3
SRE-B-15-0-3-2-1-BK-2e-BKt-5-BK	2.30 –	1.69	26.4
SRE-B-15-0-3-2-1-BK-2e-BKt-8-BK	2.34 –	1.91 +	18.5
SRE-B-15-0-3-1-3-BK-2i-BKt-6-BK	2.71	2.08 +	23.1
G38[w]	2.71	1.43 –	47.2
AGS129[w]	3.23 +	1.23 –	61.8
KS8[w]	3.40 +	1.28 –	62.2
AGS181[w]	2.56 –	1.67	34.6
TN4[w]	3.16 +	1.16 –	63.4
LSD .05	0.136		

[z]Plot size for each cultivar is 3 × 2 m, and plant density is equivalent to 200,000 plant/ha. [y]Significantly different (P 0.05) in yield from check cultivar G38. + = greater than check, – = less than check. [x]Significantly different (P 0.05) from tolerant check cultivar AGS181. + = greater than check, – = less than check. [w]Check cultivars.

Table 7. Yield and yield loss percentage of advanced breeding lines in the advanced rust tolerance trial-I grown under fungicide and nonfungicide treatments during a soybean rust epidemic in spring 1984, AVRDC.

Cultivar	Yield (t/ha)[z]		Yield Loss (%)
	fungicide-protected	unprotected	
GC60082-8-14-6-7-68	3.04 –[y]	2.17 +[x]	28.8
GC60087-7-9-6-10-31	3.17 –	2.07 +	34.7
GC60087-7-9-6-11-46	3.30	2.00 +	39.6
GC60087-7-9-6-12-8	3.14 –	2.15 +	31.4
GC60087-7-9-6-12-52	3.11 –	2.13 +	31.4
GC60031-2-7-6-6	3.14 –	1.30 –	58.7
G2120-97RR-1	2.47 –	0.74 –	70.1
G38[w]	3.31	1.63 –	50.9
AGS129[w]	3.83 +	1.39 –	63.7
AGS181[w]	2.63 –	1.73	34.2
LSD .05	0.058		

[z]Plot size for each cultivar is 3 × 6 m, and plant density is equivalent to 400,000 plant/ha. [y]Significantly different (P > 0.05) in yield from check cultivar G38; + = greater than check; – = less than check. [x]Significantly different (P > 0.05) from tolerant check cultivar AGS181; + = greater than check; – = less than check. [w]Check cultivars.

Table 8. Rates of rust development and estimated total rust-affected foliage on advanced breeding lines in the advanced rust tolerance trial-I, spring 1984, AVRDC.

Cultivar	Rate of Rust Development[z]	Rust-Affected Foliage[y](%)
GC60082-8-14-6-7-68	0.2020	4.5
GC60087-7-9-6-10-31	0.1826	11.0
GC60087-7-9-6-11-46	0.1744	11.7
GC60087-7-9-6-12-8	0.1573	13.3
GC60087-7-9-6-12-52	0.1634	12.7
GC60031-2-7-6-6	0.1218	20.5
G2120-97RR-1	0.1516	24.5
G38 (Shih-Shih)[x]	0.1778	9.1
AGS129[x]	0.2229	10.2
AGS181 (SRE-Z-11A)[x]	0.1721	8.0

[z]Regression coefficient of the correlation between total rust-affected foliage (rust-affected foliage + defoliation) and relative lifetime (DAP × 100/days to R8). [y]Estimated total rust-affected foliage when 70% of the soybean life cycle is completed. [x]Check cultivar.

Conclusion

Five lines possessed very good levels of tolerance in this spring test. Four of these lines, GC60082-8-14-6-7-68, 60087-7-9-6-11-46, 60087-7-9-6-12-8, and 60087-7-9-6-12-52, also showed very good levels of tolerance in a trial at the Hualien DAIS. The best lines in the ARTT will be selected when the trials in other environments are completed.

Rust-Tolerance Trial in Thailand

Introduction

Trials have also been conducted in Thailand to evaluate and select soybean lines with improved rust tolerance, high yield, and early maturity. Those that are more tolerant (as

determined by yield loss percentage) and higher yielding than the checks are advanced to the next IRTT. This trial was conducted in cooperation with the Chiang Mai Field Crop Research Center under the direction of Mrs. Montha Nunthapunt, the soybean plant pathologist.

Materials and Methods

Six tolerant lines were selected and planted in a 3 × 6 m plot in fall IRTT. Plant density was equivalent to 400,000 plants/ha. The check cultivars were AGS129 and 154 (high-yielding), G38 or Shih-Shih (moderately tolerant), AGS181 and 183 (highly tolerant), and 7508-50-10 (local check). A split-plot design with three replications was used. Main plots were the fungicide-protected and nonprotected treatments, and the subplots were the advanced lines and checks.

The experiment was conducted during the wet season. The fungicide used was Dithane M-45 sprayed at two-week intervals. Local cultural practices were followed. Data collected were yield, 100-seed weight, plant height, node number/plant, pod number/plant etc., and yield loss (expressed as percentage of fungicide-protected yield).

Results

One of the six tested lines, GC60082-8-14-6-7-68, yielded similarly to AGS129 (the highest yielding check) and 7508-50-10 (local check) in the fungicide-protected treatment, but yielded better than AGS181, and as well as the local check in the nonfungicide treatment (Table 9). This line was one of the highest yielding cultivars in the rust stressed treatment.

The outstanding line, GC60082-8-14-6-7-68, showed a yield loss that was considerably lower than that of AGS181 but a little more than that of the local check. GC60031-2-7-6-6 had a yield loss similar to AGS181, and therefore, a high level of tolerance but a lower yield than AGS181. GC60087-7-9-6-11-46 and GC60087-7-9-6-12-8 with a yield loss equal to or less than G38 showed moderate tolerance.

The local check cultivar, 7508-50-10, showed very high yield in the fungicide and nonfungicide treatments and a lower yield loss than AGS181. This cultivar is apparently more tolerant than AGS181, but further tests for confirmation at AVRDC and Thailand will be necessary. Plant height, node number per plant, and number of pods per plant were not greatly affected by the rust stress in this experiment (Table 10).

Table 9. Yield, yield loss percentage, 100-seed weight, and weight loss of breeding lines and commercial cultivars grown under fungicide and nonfungicide treatments during the 1984 wet season, Chiang Mai.[z]

Entry[y]	Yield[x] (kg/ha)		Yield Loss	100-Seed Wt[x] (g)		Yield Loss
	fungicide-treated	untreated	(%)	fungicide-treated	untreated	(%)
A	2310.9	2283.4	1.19	14.60	13.13	10 07
B	2253.8	1976.8	12.29	20.13	19.50	3.13
C	2253.4	1806.9	19.81	15.13	14.83	1.98
D	2088.2	1770.5	15.21	15.50	14.57	6.00
E	1820.4	1655.1	9.08	11.30	11.57	–
F	2382.3	1901.2	20.19	12.80	10.60	17.19
G	1858.9	1794.9	3.44	10.96	10.57	3.56
H	1609.8	1788.1	–	11.23	14.33	–
I	2358.5	2125.6	9.87	15.96	15.37	3.69
J	1767.3	1503.9	14.90	8.60	8.07	6.16
K	2285.3	1863.2	18.47	14.76	12.53	15.11
L	2328.9	2319.9	0.39	14.06	13.80	1.95

[z]Chiang Mai Field Crop Research Center, Thailand. [y]A: GC60082-8 14-6 68 B: GC60087-7-9-6-11-46 C: GC60087-7-9-6-12-8 D: GC60087-7-9-6-12-52 E: GC60031-2-7-6-6 F: AGS129 G: AGS154 H: SRE-B-15-0-BK-25-1-BK-2-BK-BK-BK-BK I: AGS181 (SRE-Z-11A) J: AGS183 (SRE-Z-13) K: Shih-Shih (G-38) L: 7058-50-10 (local check) [x]Mean of three replications

Table 10. Comparison of node, height, pod per plant of 12 cultivars under fungicide and nonfungicide treatments during the 1984 wet season at Chiang Mai Field Crop Research Center, 1984.[z]

Entry[y]	Plant Height[x] (cm)		No. of Node/Plant[x]		No. of Pod/Plant[x]	
	fungicide-treated	untreated	fungicide-treated	untreated	fungicide-treated	untreated
A	80.20	89.86	12.67	13.40	22.83	26.00
B	80.20	78.13	11.60	12.00	27.47	31.00
C	77.47	74.20	12.00	12.20	30.73	27.00
D	79.93	75.87	11.37	11.20	33.13	31.00
E	80.77	79.87	12.67	12.27	43.27	39.00
F	89.93	90.80	15.27	15.20	30.67	31.00
G	93.60	102.20	14.00	14.73	40.53	38.00
H	90.73	87.87	13.13	13.07	28.47	24.00
I	54.67	61.97	10.13	10.20	22.47	23.00
J	96.87	99.40	14.13	14.47	39.13	36.00
K	54.00	64.33	11.07	11.20	26.80	26.00
L	83.93	81.07	12.53	11.60	36.53	35.00

[z]Chiang Mai Field Crop Research Center, Thailand [y]A: GC60082-8-14-6-7-68 B: GC60087-7-9-6-11-46 C: GC60087-7-9-6-12-8 D: GC60087-7-9-6-12-52 E: GC60031-2-7-6-6 F: AGS129 G: AGS154 H: SRE-B-15-0-BK-25-1-BK-2-BK-1-BK-BK I: AGS181 (SRE-Z-11A) J: AGS183 (SRE-Z-13) K: Shih-Shih (G 38) L: 7508-50-10 (local check) [x]Mean of three replications.

Conclusion

GC60082-8-14-6-7-68 had a very good level of tolerance to rust and performed as well as the highest yielding check in Thailand. This line was also one of the best yielding and most tolerant lines when tested in AVRDC and Hualien and has already been selected for AVRDC's advanced yield trial. Two lines, GC60087-7-9-6-11-46 and GC60087-7-9-6-12-8 will be re-evaluated to determine their potential level for tolerance to rust.

Rust Tolerance Trial in Hualien DAIS, Spring 1984

Introduction

A rust tolerance trial was conducted at Hualien DAIS to evaluate and select soybean lines with improved rust tolerance, high yield, and early maturity under severe rust stress. Lines more tolerant (as determined by yield loss percentage) and higher yielding than the checks are advanced to the next IRTT. This trial was conducted in cooperation with the Hualien DAIS under the direction of Mr. Chen Che-ming.

Materials and Methods

Eight tolerant lines in the 1983 IRTT (fall) were selected and planted in a 2.5×2.5 m plots. Plant density was equivalent to 400,000 plants/ha. The check cultivars were AGS129 (high-yielding), G38 (moderately tolerant), AGS181 (highly tolerant), and Hualien #1 (local check). A split-plot design with three replicates was used. Main plots were fungicide-protected and nonprotected treatments, and subplots were the advanced lines and checks.

The experiment was planted on March 2, 1984. The fungicide Dithane M-45 was sprayed every two weeks starting April 2. Local cultural practices were followed. Data collected were yield, 100-seed weight, days to maturity, yield loss expressed as percentage of fungicide-protected yield.

Results

Five of the eight tested lines yielded equal to or higher than the highest yielding check in both the fungicide and nonfungicide treatments (Table 11). Yield losses of these five lines were lower than that of G38. GC60082-8-14-6-7-68 and GC60087-7-9-6-12-8 also showed a yield loss slightly less than AGS181. The yield of GC60082-8-14-6-7-68 was significantly higher than AGS181 in the unprotected treatment. GC60087-7-9-6-11-46, GC60087-7-9-6-12-52, and SRE-B-15-0-0-0-3-BK-le-BKt-1-BK showed yield losses less than that of G38 but more than that of AGS181. However, the yields of these three lines were similar to AGS181 in the unprotected plots.

SRE-B-15-0-3-2-1-BK-2e-BK-8-BK showed the lowest yield loss, and therefore, the highest tolerance to rust. Although, its yield in the untreated plots was similar to that of AGS181, its yield with fungicide protection was low.

Among the more tolerant lines, yield loss was principally due to loss in 100-seed weight (Table 11). However, in three intolerant lines, a considerable amount of yield loss was due to a reduction in seed number, probably resulting from either a reduction of nodes per plant, pods per node, seeds per pod, or a combination of all these factors. Regardless of fungicide treatment, days to maturity of all of the entries were similar to or less than those of the local check cultivar, Hualien #1.

Conclusion

Five lines, GC60082-8-14-6-7-68, GC60087-7-9-6-11-46, GC60087-7-9-6-12-8, GC60087-7-9-6-12-52, and SRE-B-15-0-0-0-3-BK-le-BKt-1-BK, were identified as having very good levels of tolerance and high yield. The GC lines have been promoted to AVRDC's advanced yield trials. All five lines will be further tested in other locations, especially Thailand, where rust is a serious problem. SRE-B-15-0-3-2-1-BK-2e-BKt-8-BK will be re-evaluated to determine its potential for use as a highly rust-tolerant parent.

Table 11. Yield, yield loss percentage, 100-seed weight and weight loss, and days to maturity of breeding lines and commercial cultivars grown under fungicide and nonfungicide treatments in spring 1984, Hualien DAIS.[z]

Entry[y]	Yield (kg/ha)		Yield Loss	100-Seed Wt (g)		Weight Loss	Days to Maturity	
	fungicide-treated	untreated	%	fungicide-treated	untreated	%	fungicide-treated	untreated
A	2077.8	1100.0	47.06	21.63	12.67	41.42	113	97
B	2222.2	955.6	57.00	27.60	16.93	38.66	118	97
C	2088.9	1066.7	48.93	25.63	16.10	37.18	118	97
D	2144.4	1022.2	52.23	25.50	16.30	36.08	118	97
E	2222.2	444.2	80.01	18.07	9.30	48.53	113	97
F	1966.7	900.0	54.24	21.60	11.93	44.77	110	103
G	1605.6	966.7	39.79	24.37	17.70	27.37	104	103
H	1655.6	788.9	52.35	21.37	11.87	44.45	118	104
I	1866.7	244.4	86.91	18.57	9.20	50.46	120	104
J	1933.3	992.2	46.68	19.20	12.47	35.05	107	106
K	1966.7	688.9	64.97	19.73	11.00	44.25	107	106
L	1700.0	322.2	81.05	23.83	12.87	45.99	116	104
LSD 5%								
within column	104.05			2.98			1.57	
between columns	145.05			3.85			1.85	
CV	15.359			10.223			0.899	

[z]Date planted March 2, 1984, date 1st sprayed, April 2, 1984, then at two-week intervals, and two weeks before harvest. [y]A: GC60082-8-14-6-7-68 B: GC60087-7-9-6-11-46 C: GC60087-7-9-6-12-8 D: GC60087-7-9-6-12-52 E: GC60031-2-7-6-6 F: SRE-15-B-0-0-0-3-BK-le-BKt-1-BK G: SRE-15-0-3-2-1-BK-2e-BKt-8-BK H: SRE-15-0-0-0-9-BK-le-BKt-4-BK I: AGS129 J: AGS181 (SRE-Z-11A) K: G38 (Shih-Shih) L: Hualien #1

Efficacy of Two *Phakopsora pachyrhizi* Biocontrol Agents under Field Conditions

Introduction

Two fungi, a *Gliomastix* sp. and a *Trichothecium* sp. found growing on soybean rust lesions at AVRDC, have been isolated and subsequently observed for hyperparasitism. Previous observations showed that both fungi reduced the reproductive capacity of the rust fungus, which should lead to a reduction in the rate of disease development resulting in reductions in yield loss. This indicated that both fungi were potential biocontrol agents. The purpose of this study was to determine if these agents could reduce the rate of rust development in the field.

Materials and Methods

The experiment was conducted in spring 1984. A randomized complete block design with four replications was used. Plot size was 4 × 6 m. Soybean cultivar Shih-Shih (G38) was grown at a density equivalent to 200,000 plants/ha. Treatments applied in the experiment were as follows: (1) inoculation of *Gliomastix* sp., (2) inoculation of *Trichothecium* sp., (3) spraying of protective fungicide Dithane M-45 at 1:400 dilution, and (4) check.

Plants of all plots were inoculated five times with a *Phakopsora pachyrhizi* uredospore suspension from April 3 to 24 before the application of any treatment. The treatments were first applied at the R5.3 growth stage (May 2, 1984) when the plants appeared to have about 1% rust on the leaflets, and then the treatments were continued once every two weeks.

Data were recorded at weekly intervals to evaluate rust development, including growth stage, defoliation, and percentage of rust severity. Yield per plot and 100-seed weight data were collected at harvest. Yield data were converted to yield per hectare at 13% moisture content before evaluation.

Results

Rust development in this experiment was very late. The 1% level of severity was attained only on May 1 (56 DAP, R5.5 growth stage) even after repeated artificial inoculations. The late development of the epidemic and the artificial inoculations resulted in a high rate of rust development.

Rust development in the plots inoculated with the biocontrol fungi was similar to that of the nonprotected check treatment. The rate of rust development in the plots inoculated with the biocontrol agents *Gliomastrix* sp. and *Trichothecium* sp. were 0.255 and 0.254, respectively, compared with 0.227 of the unprotected check and 0.096 of the fungicide-protected check (Table 12). This means that epidemic development, from 1% development to complete defoliation, was accomplished in less than 27 days in the unprotected treatments.

Even though rust developed late in the growing season, yield losses were substantial. Yield losses, based on the fungicide-protected check, were 42% and 41% in the plots protected by the two biocontrol fungi (*Gliomastrex* sp. and *Trichothecium* sp., respectively) and 39% in the unprotected plots (Table 13). The rate of rust development in these plots was highly and negatively correlated with yield ($r = -0.994^{**}$). Yields in the unprotected treatments and those inoculated with the biocontrol agents were not significantly different but were significantly lower than those in the fungicide-protected plots.

Conclusion

Dithane M-45 is a protective fungicide widely recommended to control soybean rust. Its efficacy is clearly shown by the greatly reduced rate of rust development under heavy inoculum pressure from five artificial inoculations, as well as from natural inoculum.

The efficacy of the two biocontrol organisms was not confirmed in this field study. The rapid rate of rust development and high inoculum pressure is the most probable reasons for the failure of the biocontrol agents to cause a reduction in the rate of rust development. Previous studies have shown that these fungi need either necrotic soybean tissue or mature (open) uredia of *P. pachyrhizi* for their growth and development.

Also, the reproductive capacity of *P. pachyrhizi* uredia continued for approximately two weeks after inoculation with spores of the biocontrol agents. The principal effect of these agents is to shorten the reproductive duration of the rust uredia by 60 to 80%. Consequently, the biocontrol agents would not be effective in situations with high inoculum pressure and rapid rust development. Further studies are in progress.

Table 12. Rates of rust development on soybean plants inoculated with biocontrol organisms or protected with fungicide.

Treatment	Rate of Rust Development[z]	Intercept of Linear Regression	r-Value
Inoculated with *Gliomastix* sp.	0.255	-20.84	0.984
Inoculated with *Trichothecium* sp.	0.254	-20.89	0.982
Protected with Dithane M-45	0.096	-10.12	0.835
Unprotected Check	0.227	-18.91	0.986

[z]Regression coefficient of the correlation between logit of disease severity and relative lifetime (RLT = DAP × 100/days to R8).

Table 13. The effect of potential biocontrol organisms and Dithane M-45 on the yield and yield loss percentage of soybeans affected by soybean rust.

Treatment	Yield[z] (kg/ha)	Yield Loss (%)
Inoculated with *Gliomastix* sp.	1594.6	41
Inoculated with *Trichothecium* sp.	1572.5	42
Protected with Dithane M-45	2724.4	0
Check	1662.9	39
LSD .05	203.8	

[z]At 13% moisture content.

The Effect of Different Fungicide Spray Schedules on Two Soybean Cultivars with Rust Tolerance

Introduction

Yield losses as high as 90% from soybean rust, caused by *Phakopsora pachyrhizi* H. and P. Syd. have been recorded, and losses from 20 to 60% are not uncommon. The ideal method for controlling this disease is to grow cultivars with high levels of rust resistance or tolerance; however, these cultivars are not yet available. Therefore, fungicides are necessary to obtain high yields in areas where rust is a serious problem. This experiment was designed to evaluate the effect of fungicide schedules on the yield loss of cultivars with different levels of tolerance to rust.

Materials and Methods

The experiment was conducted using a split-plot design with four replications in the spring season. The main plots were five different spray initiation dates: three weeks (F3), five weeks (F5), seven weeks (F7), nine weeks (F9), and eleven weeks after planting (F11). This last date was also the unsprayed check treatment (Ck) because spray initiation nearly

coincided with maturity, and the fungicide was not applied. The fungicide was Dithane M-45 at a 1:400 dilution and applied at two-week intervals after initiation. The number of fungicide applications in the main plots and subplots is shown in Table 14.

The subplots were three soybean cultivars, AGS181 (SRE-Z-11A), G38 (Shih-shih), and G2041 (TK#5). AGS181 is rated as highly tolerant to rust, G38 as moderately tolerant and the most tolerant commercial cultivar yet identified, and G2041 as highly intolerant. Unfortunately, G2041 had to be dropped from the experiment because of severe lodging.

Subplot size was 4 × 6 m with a plant density equivalent to 400,000 plants/ha. All plants were inoculated three times with a rust uredospore suspension between the V2 and V4 growth stages. Yield data were converted to 13% moisture content before evaluation.

Results

Rust development did not occur until late in the growing season after the first rain. Differences in rust severity and defoliation between treatments were first observed at 59 DAP, R5.8 (G38), and R6.0 (AGS181) growth stage. However, maximum yield losses based on the F5 yield was 31% and 48% for AGS181 and G38, respectively (Table 14).

Table 14. Yields of rust-infected soybean cultivars protected with Dithane M-45 and the profit or loss associated with fungicide application.

Fungicide Spray Schedule	Cultivar					
	AGS181			G38		
	yield (t/ha)	fungicide application	loss[z] (US$/ha)	yield (t/ha)	fungicide application	loss (US$/ha)
F3	2.61	5	125	2.85	5	131
F5	2.74	4		3.00	4	
F7	2.49	3	120	2.24	3	432
F9	2.06	1	308	1.72	2	722
Ck	1.89	0	377	1.56	0	742

[z]Loss = US$0.625/kg × (yield F5 − yield F_n) − (cost differential of spray application). US$0.625 is the current government support price for soybeans. The estimated fungicide application cost is US$39.38/ha, calculated as fungicide cost (US$3.75/kg × 2.5 kg/ha) + labor cost (US$20.00/man-day × 1.5 man-days/ha). Conversion of US$ to NT$ = 1:40

Yield of both cultivars in the F5 spray schedule was the highest of any treatment and slightly higher even than that of the F3 schedule (Table 14). This phenomena, where a low level of disease stimulates a yield increase, is a common occurrence in many diseases. The F5 treatment yield is used as the maximum fungicide-protected yield.

In the F5 treatment, G38 outyielded AGS181 by 260 kg/ha; however, AGS181 outyielded G38 by 250 kg/ha in the F7 treatment. The difference between these two treatments was one fungicide application (Table 14). This example clearly showed the advantage of using a more tolerant cultivar when full fungicide protection can not be attained.

The earlier initiation of the fungicide spray schedule between the check and F5 treatments was highly correlated with increased yields (r^2 91% and 88% for AGS181 and G38). For each two weeks earlier that the spray schedule was initiated, including 5 WAP, an estimated yield increase of 299 and 485 kg/ha was expected for AGS181 and G38, respectively.

Losses associated with fungicide usage ranged from US$120 to US$742 depending on the spray schedule and cultivar (Table 14). Losses due to a nonoptimal fungicide spray schedule were greatest in the less tolerant cultivar, G38, principally because of its higher rate of yield loss. Therefore, in an environment where rust is a serious problem, the risk is greater when growing G38 in fungicide spray schedules that cannot be optimized, either because of financial or management reasons.

Conclusion

The early application of fungicides to protect soybean in a severe rust epidemic is highly profitable. The use of more rust-tolerant soybean cultivars lowers the risk associated with the decision to initiate a fungicide spray schedule. The development of economical fungicide application schedules and concentrations need to consider both the expected rust severity and the level of cultivar resistance or tolerance.

Screening for Bacterial Pustule Resistance

Introduction

Bacterial pustule caused by *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye, can cause serious yield losses and is certainly one of the most important diseases when soybeans are planted during the warm, humid, rainy season in Southeast Asia. The main effect of the disease is to cause a reduction in photosynthetic capacity and premature defoliation, resulting in fewer, smaller seeds. Differences in varietal reaction to the disease were first reported in 1928. CNS, used as the source of bacterial pustule resistance in almost all cultivars grown in southern USA, was identified in 1943. The CNS level of resistance is described as near immunity and is conferred by a single recessive gene. However, trials at AVRDC and field observations in Southeast Asia have indicated that the level of resistance in CNS at best is only moderately resistant.

In the first screening trials in 1976, AVRDC identified three accessions, G8190 (PI371611), G8499 (PI189402), and G8823 (PI374157), as having levels of resistance higher than CNS. This year's trial screened and evaluated germplasm accessions thought to have bacterial pustule resistance and also screened and evaluated most of the AGS lines.

Materials and Methods

One hundred and seventy-two AGS lines and 63 accessions were planted in 1 × 1 m plots at a plant density equivalent to 200,000 plants/ha with three replications. The check cultivars were G8190 (highly resistant), CNS (moderately resistant), and G38 (highly susceptible). THe experiment was planted on June 22, 1984 and artificially inoculated on July 19, 1984.

The inoculum was prepared by homogenizing seriously infected soybean leaves in a blender and then filtering the homogenate through two layers of nylon net to obtain a bacterial suspension. The suspension was then diluted in water and a sticker-spreader was added. Inoculation was accomplished by forcibly spraying the dilute suspension on both leaf surfaces with an atomizer attached to a high pressure (25 kg/cm^2) pump.

Disease ratings were made one month following inoculation and again 10 days later after the second and third infection cycles. Resistance evaluation was based on the following rating system: highly resistant (HR) = disease severity similar to or less than that of G8190; moderately resistant (MR) = disease severity similar to that of G2034 (CNS); moderately susceptible (MS) = disease severity distinctly more than that of G2034; and highly susceptible (HS) = disease severity similar to or greater than that of G38. G8190 and CNS were selected as the HR and MR checks based on the results of previous screening/evaluation trials for bacterial pustule resistance and observations at AVRDC.

Results

Thirty-nine cultivars (21 AGS lines and 18 germplasm accessions) were rated highly resistant to bacterial pustule (Table 15). Thirteen of these AGS lines were the result of the crossing program (GC lines), and the other eight AGS lines were accessions. All of these 13

highly resistant AGS/GC lines resulted from two crosses, Shih-shih × SRF400 and SRF400 × PI 297550 (Table 16). SRF400 is a narrow leaflet type as are all of its highly resistant progeny. Apparently, SRF 400 is a source of pustule resistance; however, we have not yet screened and evaluated this cultivar to determine its level of resistance to it.

The pedigrees of 10 of the 18 accessions rated as highly resistant were identified (Table 17). In all 10 accessions the cultivar CNS was used as a parent and most probably as the source of pustule resistance. However, their level of resistance was higher than that of G2034, our accession listed as CNS.

Thirty-three cultivars, 13 AGS lines, and 20 accession were rated as moderately resistant to bacterial pustule. Three of the 13 AGS lines were accessions listed as AGS lines (Table 15).

All AGS lines from 180 to 290, inclusive, were evaluated in this trial. However, only one AGS line that resulted from the crossing program (i.e., not an accession or from an accession) was rated as either moderately or highly resistant. This line, AGS 264, was rated moderately resistant.

Conclusion

Rated as either highly resistant or moderately resistant were 14% of the 152 GC lines listed as AGS lines. However, only one AGS/GC line developed since AGS180 is resistant to bacterial pustule. The aim to incorporate bacterial pustule resistance into our advanced lines needs to be emphasized. Twenty-six accessions and accessions listed as AGS lines were rated highly resistant. These accessions, as well as the highly resistant AGS lines, would be useful sources of bacterial pustule resistance in our soybean improvement program.

Table 15. Disease reaction of soybean accessions and breeding lines to bacterial pustule, summer 1984, AVRDC.

Disease Reaction[z]	No. of Entry	Percentage	AGS Lines	Percentage	No. of Accs.	Percentage
HR	39	16.6	21(13)[y]	12.2(8.6)	18	28.6
MR	33	14.0	13(10)	7.6(5.0)	20	31.8
MS	94	40.0	73(69)	42.4(45.4)	21	33.3
HS	69	29.4	65(60)	37.8(39.5)	4	6.4
Total	235		172		63	

[z]Disease reaction: HR = disease severity similar to or less than G8190, MR = disease severity similar to G2034 (CNS), MS = disease severity distinctly greater than G2034, HS = disease severity similar to or greater than G38. [y]Numbers in parentheses are for GC lines within AGS lines.

Table 16. AGS lines highly resistant to bacterial pustule, summer 1984.

Glycine Cross (GC) Lines		Others	
AGS no.	parentage	AGS no.	accession no./name
9	Shih-Shih × SRF 400	190	Vesoy #4
19	Shih-Shih × SRF 400	191	BPI #4
62	SRF 400 × PI 297550	268	G10446 (Siatsa 194)
128	SRF 400 × PI 297550	269	G10467 (PK7386)
129	Shih-Shih × SRF 400	270	G10468 (PK7394)
138	SRF 400 × PI 297550	272	G10470 (Foster)
139	SRF 400 × PI 297550	273	G10471 (CEP 7177)
141	SRF 400 × PI 297550	275	G10452 (Duo Crop)
142	SRF 400 × PI 2975509		
147	Shih-Shih × SRF 400		
149	SRF 400 × PI 297550		
152	SRF 400 × PI 297550		
153	SRF 400 × PI 297550		

This test confirms the results of previous tests and observations. In Taiwan, the soybean cultivar CNS (G2034) is not nearly immune to bacterial pustule as has previously been reported in the USA. This would indicate that: 1) a new race of the pathogen exists; 2) G2034 is not CNS; or 3) our environment is more conducive to bacterial pustule development. This phenomenon will be further investigated. The resistance evaluations will be confirmed next year.

Table 17. Soybean accessions highly resistant to bacterial pustule, summer 1984, AVRDC.

Acc. No.[z]	Cultivar Name	Pedigree
G2025	Hutton	F55-822//Roanoke/CNS-4
G2035	Bragg	Volstate/Palmetto//S-100/CNS
G2296	Bossier	S-100 x CNS
G4493	PI171445	–
G5087	Cobb	Roanoke//Ogden/CNS///Pelican////Volstate/ Palmetto/S-100/CNS
G5090	Tracy	Dunfield/Haberlandt//Sib of Lee/PI 171442/// F.C. 31745//S-100/CNS
G5288	Custer	[((Peking///S-100/CNS//Lincoln/Richland) x (Peking///S-100/CNS//Lincoln/Richland)) x S-100/CNS//Lincoln/Richland///Blackhawk] x (Peking///S-100/CNS//Lincoln/Richland)
G5425	Scott	S-100/CNS///Mandarin/Manchu//Richland
G7965	Hill	Dunfield/Haberlandt//S-100/CNS
G8190	PI 371611	–
G8339	PI 219656	–
G8451	PI 165676	–
G8467	PI 171446	–
G8499	PI 189402	–
G8598	Bragg	Volstate/Palmetto//S-100/CNS
G8651	La Green	Unknown
G8657	Otootan	From Taiwan via Hawaii
G8672	Hutton	F55-822//Roanoke/CNS-4

[z]The resistance of these accessions is better than CNS (G2034).

The Relationship among Seed Weight, Seed-Borne Diseases, and Germination of Soybean AGS Lines Harvested, Summer 1984

Introduction

The failure to produce soybean seeds with high germinability during the rainy season has been one of the factors limiting soybean production in southeast Asian countries. Many factors are known to be associated with germination of soybeans, such as: harvesting, drying and threshing processes, storage conditions, environmental factors, seed size, and seed-borne pathogens. This investigation was conducted to evaluate the variation in and interrelationship of 100-seed weight, frequency of diseased seeds, and germination among AGS lines harvested during the rainy season.

Materials and Methods

To determine the frequency of diseased seeds, mature soybean seeds from 178 AGS lines were harvested in June and July from a spring-planted (March 8, 1984) disease nursery. After threshing, 100 seeds in each of two replications of each line were collected at random and assessed visually for disease symptoms on the seed coat.

To determine seed germination percentage, another 100 seeds in each of two replications of each line from the same experiment were randomly collected. Then, 10 seeds of each line were planted in six-inch (diameter) clay pots with nonsterilized soil (soil, compost, sand, rice hull at a ratio of 5:3:1:1) and put outside the greenhouse. The experiment was repeated three times, with the first experiment planted on August 16 (30 seeds) and the others on August 30 (30 seeds) and September 12 (40 seeds). Percentage germination was evaluated after the first trifoliate leaf appeared.

Results

As the seeds were collected during the rainy season, a number of disease symptoms were observed on the seed coat. The most frequently observed symptoms were caused by *Collectotrichum* sp., *Phomopsis* sp., *Cercospora kikuchii*, and soybean mosaic virus.

Among the 178 AGS lines tested, the frequency of visually assessed disease-free seeds ranged from 19 to 98% (Table 18), the germination ranged from 5 to 81% (Table 19), and the 100-seed weight from 5.8 to 27.4 g (Table 20). However, only eight lines had 100-seed weights equal to or greater than 20 g.

The best 20 AGS lines with respect to germinability were also relatively free of seed-borne diseases, with less than 21% infected seeds. They were small-seeded (less than 11.4 g/100 seed), except for AGS193 (Table 21). The pedigrees of these lines (Table 22) indicate that 10 of the lines resulted from the same cross, CH#2 × KS528. Apparently, these AGS lines and their two parents are promising sources for improving germinability and resistance to seed-borne diseases. However, additional studies will be necessary.

An evaluation of all 178 AGS lines showed a highly significant correlation between 100-seed weight and germination ($r = -0.5628$) and between the percentage of disease-free seeds and germination ($r = 0.5328$). However, the two correlations only account for 32% and 28% of the variation, respectively. The correlation between 100-seed weight and percentage of disease-free seeds was significant ($r = -0.1905$); however, the relationship between these two factors was very low ($r^2 = 0.04$).

Some of the unaccounted variations in the correlation between percentage of disease-free seeds and germination may be due to the fact that some of the seeds without symptoms were actually infected with pathogens, and that some of the pathogens that produced seed-coat symptoms did not affect the germination of the seed.

Conclusion

Low correlation between 100-seed weight and percentage of disease-free seeds indicated that cultivars with high levels of resistance to seed-borne diseases have better seed germinability regardless of seed size.

Table 18. Frequency of disease-free seeds of 178 AGS lines harvested during the rainy season, summer 1984, AVRDC.[z]

Disease-Free Seed (%)[z]	No. of AGS Lines	Percentage of Total
90	12	6.7
80-90	53	29.8
70-80	60	33.7
60-70	34	19.1
50-60	10	5.6
40-50	4	2.3
30-40	3	1.7
20-30	1	0.6
10-20	1	0.6
Total	178	

[z]Evaluated were 100 seeds of each of two replications in each line.

Table 19. Percentage germination of 178 AGS lines.[z]

Germination[y] (%)	No. of Lines	Percentage of Total
>80	1	0.6
70-80	7	3.9
60-70	14	7.9
50-60	36	20.2
40-50	45	25.3
30-40	47	26.4
20-30	15	8.4
10-20	10	5.6
<10	5	2.8
Total	178	

[z]Based on 100 seeds/line. [y]Germination percentage was determined after the first trifoliate leaf appeared.

Table 20. Percentage of 100-seed weight of 178 AGS lines.

Range of 100-Seed Wt (g)	No. of Lines	Percentage of Total
>26[z]	1	0.6
24-26	1	0.6
22-24	2	1.1
20-22	2	1.1
18-20	3	1.7
16-18	9	5.1
14-16	23	12.9
12-14	48	27.0
10-12	50	28.1
<10[y]	39	21.9
Total	178	

[z]The highest 100-seed weight was AGS187 (27.4 g). [y]The lowest 100-seed weight was AGS171 (5.8 g).

Table 21. The relationship between seed weight, seedborne diseases, and germination of soybean AGS lines from the 1984 rainy season harvest.[z]

AGS#	100-Seed Wt	Germination (%)	Disease-Free Seeds (%)
92	8.2	80.57	82.00
91	8.7	78.33	88.50
88	9.2	76.93	92.50
53	9.8	73.60	86.00
18	9.8	72.77	88.50
90	8.8	72.77	89.50
93	9.3	70.87	89.50
99	9.9	70.53	91.50
55	11.4	68.63	80.50
59	9.4	68.00	90.50
89	8.8	68.60	93.00
95	8.3	67.50	85.00
217	11.1	66.97	86.50
38	9.8	66.67	85.50
157	10.5	66.10	85.00
94	9.2	65.53	91.00
231	10.5	65.27	84.00
54	8.5	64.70	91.50
30	8.5	63.87	79.50
193	16.8	63.60	88.00

[z]The data were the mean of two replications.

Table 22. The pedigrees of 20 AGS lines with the highest germinability.

AGS #	Pedigree	AGS #	Pedigree
92	CH #2 x KS528	89	CH #2 x KS528
91	CH #2 x KS528	95	CH #2 x KS528
88	CH #2 x KS528	217	Clark 63 x PI248407
53	Wayne x PI96983-Ped	38	Wayne x PI96983-Ped
18	PI189876 x CH #2	157	Eassex x 64-64
90	KS460 x Yagi 1	94	CH #2 x KS528
93	CH #2 x KS528	231	Tokachinagata x AGS2
99	CH #2 x KS528	54	CH #2 x KS528
55	KS482 x Loe	30	Clark 63 x Palmetto
59	CH #2 x KS528	193	KS739 x Akiyoshi

Effect of Benomyl Spray Schedules on Seed Quality of Soybeans Grown during Spring and Summer 1984

Introduction

Seed-borne fungi can reduce seed quality and serve as a source of primary inoculum for these pathogens, increasing disease incidence and pathogens in the subsequent crop. Therefore, the benefits of controlling seed-borne pathogens go beyond increasing yield, the parameter most frequently used to justify seed treatments and fungicide sprays.

Efforts are necessary to study the effect of fungicide treatment before harvest on the amount of seed infection and germinability. This experiment was conducted to evaluate the best spray schedule for applying benomyl to control seed-borne diseases prior to harvest.

Materials and Methods

The experiment consisted of a nonfungicide treatment and three fungicide spray treatments, with each spray schedule starting at a different growth stage and then continuing through to harvest. The spray schedules started at the R1, R3, and R5 growth stages. The fungicide used was benomyl (benlate) at a dilution of 1:1,000 applied at two-week intervals. Four sprays per treatment were used starting from R1, three from R3, and two from R5.

The soybean cultivar Taita Kaohsiung No. 5 (TK#5) was planted in 3 x 6 m plots in a randomized complete block design with three replications and at a plant density equivalent to 400,000 and 200,000 plants/ha in the spring and summer plantings, respectively. The spring experiment was planted on March 13 and the summer, on June 14. The spring planting was harvested after the beginning of the rainy season. The summer planting was grown during the rainy season and harvested after the end of the rainy season. Data collected were on yield, 100-seed weight, and seed quality which included the percentage of disease-free seeds, diseased seeds, and small seeds.

After the evaluation of seed quality, fifty seeds for the germination test were randomly selected from each treatment and replication and planted in black plastic flats containing sterilized potting soil (composed of soil, compost, rice hull, and sand at a 5:3:1:1 ratio).

Results

In both plantings, the benomyl fungicide sprays increased yield, days to maturity, 100-seed weight, percentage of disease-free seeds, and seed germination, and decreased the percentage of diseased seeds. However, yield, 100-seed weight, seed germination, and percentage of disease-free seeds were much lower and the percentage of diseased seed higher in the spring planting (Table 23) than in the summer planting (Table 24). The percentage of

disease-free seeds in the most frequently sprayed treatment (initiated at R1) in the spring planting was greater than that in the untreated plots in the summer planting.

Low grain yield in the spring planting was partially due to a severe soybean rust epidemic which was not adequately controlled by the benomyl spray. Yield and seed quality were highest in the most frequently sprayed treatment during the spring season. In the summer season, the least frequently sprayed treatment (initiated at R5) was as good as the other treatments.

Conclusion

Benomyl improved seed quality and yield in both seasons, although the improvement in the spring season was inadequate. Rainfall late in the soybean-growing season is apparently more conducive to seed infection than is rainfall during the early and middle portions of the growing season. Also, the presence of other diseases, such as rust, may predispose the plant to infection by seed-borne pathogens. Further studies will be undertaken to determine the factors involved in the high frequency of seed-borne diseases in the spring planting.

Table 23. The effect of different fungicide spray schedules on soybean seed quality and yield during the spring season.[z]

Spray Initiation	Days to Maturity	Yield (kg/ha)	100-Seed Wt[y] (g)	Seed Quality (%)			Germination (%)
				disease-free	diseased seeds	small seeds	
R1	100.0	1132.21	10.45	62.0	18.0	20.0	57.30
R3	97.0	683.69	9.31	60.0	26.7	13.3	52.67
R5	97.0	513.88	8.31	48.3	26.0	25.3	42.0
Control	94.3	476.91	7.84	42.3	30.3	27.3	34.0
LSD 5%	2.31	443.43	1.85				
1%	3.50	671.76	2.81				
CV	1.19	31.63	10.33				

[z]Planted: March 13, 1984; variety: TK #5; fungicide spray: Benlate 50% w.p., 1000X dilution, at two-week intervals; plot size: 3×6 m. [y]At 13% water content.

Table 24. The effect of different fungicide spray schedules on soybean seed quality and yield during the summer season.[z]

Treatment Spray Initiation	Days to Maturity	Yield (kg/ha)	100-Seed Wt[y] (g)	Seed Quality (%)			Germination (%)
				disease-free	diseased seeds	small seeds	
R1	101	2150.53	12.72	95.9	0	4.1	93.0
R3	100	1989.42	12.03	95.4	0	4.6	90
R5	99	1917.09	11.97	96.8	0	3.2	89.3
Control	91	1240.06	9.36	86.7	1.1	12.5	76.7

[z]Planted: June 14, 1984; variety: TK#5; fungicide spray: Benlate 50% w.p., 1000X dilution, at two-week intervals; design: randomized complete block; plot size: 3×6 m. [y]At 13% water content.

Effect of Seed Treatment on Germination of Soybean

Introduction

Soybean is attacked by a wide range of diseases, many of them seed-borne. Microorganisms that invade and colonize soybean seeds before harvest can reduce yield, seed quality, and plant stand, as well as serve as inoculum source for the subsequent crop grown from these seeds. Seed infection is also a means of survival for these pathogens. Some seed-borne pathogens frequently produce distinctive symptoms on infected seeds and therefore, can be removed from the seed lot. However, many infected seeds show no visible symptoms.

Seed treatment is probably the cheapest and often the safest chemical control method for seed-borne diseases and for improving germination of poor quality seeds in the field. This experiment on screening fungicides for use as a seed treatment is a preliminary study conducted during the summer season.

Materials and Methods

The experiment consisted of six fungicide treatments and one control: (1) Difolatan 80% w.p. at 0.25% (w/w); (2) Captan 50% w.p. at 0.5% (w/w); (3) Benlate 50% w.p. at 0.2% (w/w); (4) Arasan 65% w.p. at 0.2% (w/w); (5) PCNB 75% w.p. at 0.125% (w/w); and (6) PCNB 75% w.p. at 0.125% and Captan 50% w.p. at 0.5% (w/w).

Three soybean cultivars, TK#5, AGS129, and AGS181 were used in this experiment; and the seeds were collected from different experiments harvested in spring 1984. Three germination environments were used: greenhouse (24° to 35°C), growth room (18 ± 2°C), and outside (23° to 33°C).

Seeds of each cultivar were coated with one of six fungicides at the ratios described above. All were coated in a similar manner. Then, five seeds were planted into each of four pots, each pot being one replication,for each treatment on June 26, 1984. Clay pots, 17.5 cm in diameter, with 3.65 kg of nonsterilized soil (composed of soil, compost, sand, and rice hull in a 5:3:1:1 ratio) were used inside and outside the greenhouse. Clay pots, 12 5 cm diameter, with 1.20 kg of soil were used in the growth room. Germination was evaluated when the first trifoliate leaf appeared.

Results

Seed treated with Arasan, Difolatan, PCNB + Captan, and Captan showed the highest percentage germination under greenhouse conditions (Table 25). Captan, PCNB + Captan, Arasan, and PCNB gave the best results under cool temperatures in the growth room. These

Table 25. Seed treatment effect on the germination of soybean seed under different conditions.

Environment[z]	Variety[y]	Germination[x](%) Treatment[w]						
		A	B	C	D	E	F	G
Inside the greenhouse (24-35°C)	TK#5	85.0	75.0	75.0	100.0	40.0	95.0	15.0
	AGS129	95.0	100.0	10.0	100.0	25.0	90.0	30.0
	AGS181	85.0	80.0	15.0	85.0	35.0	75.0	35.0
	Mean	88.3	85.0	33.3	95.0	32.3	86.7	26.7
Growth room (18 ± 2°C)	TK#5	80.0	90.0	60.0	90.0	90.0	90.0	85.0
	AGS129	100.0	95.0	95.0	100.0	100.0	100.0	100.0
	AGS181	55.0	95.0	80.0	75.0	70.0	80.0	65.0
	Mean	78.3	93.3	78.3	88.3	86.7	90.0	83.3
Outside the greenhouse (23-33°C)	TK#5	75.0	58.3	58.3	70.8	58.3	87.5	58.3
	AGS129	95.8	83.3	58.3	91.7	45.8	87.8	62.5
	AGS181	70.8	70.8	58.3	70.8	54.2	66.7	58.3
	Mean	80.5	70.8	58.3	77 8	52.8	80.7	59.7
Mean in three conditions		82.4	83.0	56.7	87.0	57.5	85.7	56.6

[z]Planted: June 26, 1984. [y]The seeds were collected from different experiments harvested in spring, 1984. [x]Four replications were used in each treatment. Five seeds were planted in a 17 5 cm diameter clay pot as a replicate. Each pot contained 3 65 kg nonsterilized soil. Only 12.5 cm pots with 1.2 kg soil were used in the growth room. [w]Treatments: A = 80% w.p. Difolatan; B = 50% w.p Captan; C = 50% w.p. Benlate; D = 65% w.p. Arasan; E = 75% PCNB; F = Captan + PCNB; G = Ck.

temperatures were similar to the mean temperatures during the spring planting period (mid to late February). Seed treated with PCNB+Captan, Difolatan, Arasan, and Captan satisfactorily improved germination in the ambient conditions outside. This was surprising considering that 97 mm of rain fell during the ten days of this experiment.

Conclusion

Three fungicides, Arasan, Captan, and PCNB+Captan, were effective as seed treatment under all three environmental conditions. The results will be confirmed in the future.

Infection of Rice Seedlings by VAM Fungi

Introduction

In the past, infection of rice seedlings by the VAM fungi associated with the rice-rice-soybean cropping system has been erratic and seasonally dependent. Infection of rice seedlings by VAM fungi beneficial to soybean prior to transplanting could be a feasible method for altering the VAM fungal population in these fields for the benefit of the subsequent soybean crop. This technique could be most effective when soybeans are planted into the rice stubble because the soybean roots would be in close proximity to the rice roots. The purpose of this experiment was to determine the infectivity of VAM fungi on rice and identify the inoculation technique that allows the best results.

Materials and Methods

Two VAM species, two inoculation methods, and three phosphate levels were used in this experiment. The VA mycorrhizal species were *Glomus mosseae* and *G. etunicatus*. The inculation methods were spores layered halfway between the surface of the growth medium and the bottom of the pot, and spores applied in multiple layers within the growth medium.

Three levels of phosphate applied as $CaH(PO_4)_2$ were full phosphate (8g/5 kg soil, equivalent to the amount applied by rice seedling producers), half phosphate (4 g/5 kg of soil), and no phosphate. The growth medium was mixed soil and rough sand at a ratio of 2:1 (w:w). After inoculation and sowing of the rice seed (cultivar Tainung No. 67), the pots were placed in the greenhouse. Rice roots were sampled, cleared, and satined every five days and examined microscopically for infection by the VAM fungi.

Results

Only *G. mosseae* was mycorrhizal on rice seedlings. Infection was first observed at five days after planting; however, the percentage of mycorrhizal roots was very low until twenty days after planting (Table 26). *G. etunicatus* failed to produce any evidence of infection, internal hyphae, or arbuscula during the 25 days of the experiment.

Infection rate decreased with decreasing levels of phosphate fertilization (Table 26). The inoculation method had little effect on infection rate; therefore, both methods are equally good for mycorrhizal infection.

Conclusion

G. mosseae was mycorrhizal on rice and *G. etunicatus* was not. This confirmed results from our previous experiments. High phosphate levels did not decrease the infection rate of rice seedlings by *G. mosseae*. Therefore, the current rates of phosphate fertilization used by rice seedling producers should not affect the establishment of *G. mosseae*.

Table 26. Infection rate of rice inoculated with *G. mosseae* in three fertilizer regimes in the greenhouse.

	Days after Planting				
	5	10	15	20	25
Multilayer Inoculum					
Full phosphate					
root length (mm)	36	326	528	618	971
infection rate (%)	0	0	0	2.5	12.6
Half phosphate					
root length (mm)	22.4	273	396	453	880
infection rate (%)	0	0	0	1.4	9.5
No phosphate					
root length (mm)	29	234	333	414	598
infection rate (%)	0	0	0	0	2.9
Single-Layer Inoculum					
Full phosphate					
root length (mm)	37	262	304	525	888
infection rate (%)	0	0	0	1.9	18.6
Half phosphate					
root length (mm)	37	333	361	537	735
infection rate (%)	0	0	0	0	11.6
No phosphate					
root length (mm)	22	293	343	505	400
infection rate (%)	0	0	0	0	0.38

Further Identification of Unknown Soybean Virus Isolates

Introduction

In previous surveys of soybean growing areas a POT-Y virus was isolated that could not be exactly identified. In ELISA it reacted positively with BCMV, AzMV, and BICMV antisera. Therefore further hosts, particularly those commonly used for the identification of BCMV (*P. vulgaris* cvs. Redlands Greenleaf C, Redlands Greenleaf B, Great Northern 123, Sanilac, Monroe, Jubila, Improved Tendergreen, Amanda), and BICMV (*P. vulgaris* cvs. Black Turtle I and Black Turtle II, *Vigna sinensis* TUV 2480 and Blackeye) were tested. Additional serological tests were also conducted.

Materials and Methods

Four to eight plants were inoculated with a 1:3 homogenate of freshly infected leaves in 0.1M phosphate buffer pH 7.2. Symptomless plants were checked by ELISA.

Serology. The isolates PM, PN, and 74 were tested in agar gel double diffusion tests with five antisera: AzMV-AS, BICMV-AS, SMV-AS (ATCC), PN-AS, and M4-AS.

Antigens were prepared by macerating 1 part of *G. max* TN4, infected with each virus isolate in one part PDS buffer containing 1.5% SDS, and were placed in peripheral wells. An undiluted antiserum was added to the central wells at 8.5 mm distance from the peripheral wells. Homologous antigens were used for SMV-AS, PN-AS, and M4-AS only. BICMV and AzMV antigens were not available at the time of the test due to quarantine regulations.

Seed transmission. A number of locally grown soybean cultivars were mechanically inoculated with the unknown isolates. Seeds were collected and, germinated, and infected plants were recorded.

Results

The following hosts could be systemically infected with all three virus isolates (S-PN, S-PM, S-74): *Cassia occidentalis, Cyamopsis tetragonoloba, Dolichos labalab, G. max* cvs. Bragg, Rampage, Davis, York, Marshall, Ogden, Buffalo, Iwate-Wasekurome, Toyosuzu, Tainung No. 3, Tainung No. 4, HL-1, AVRDC G-2, G10134, and G10466, Talientou, Kaohsiung No. 9, Mou Dou 205, TAM (Malaysia), *P. acutifolius* PI200749, *P. lathyroides, P. vulgaris* cvs. Bountiful, Black Turtle II, *Vigna angularis* cvs. Jen Sen, Odate No. 1, Shiroazuki, *Vigna mungo* Acc. 3115, *Vigna unguiculata,* Blackeye, Blue Coose, Early Ramshorn, Kaohsiung Green Pod; *Vigna sesquipedalis* cvs. Bogor I, Tainung 3, White Pod, Green Pod, Dagupan Pangasinan Coll. 1.1, Dagupan Pangasinan Coll. 1.3., 20-2, and *Nicotiana benthamiana.* On these hosts, mosaic often accompanied by systemic necrosis was produced. The reactions on the following *P. vulgaris* cvs. (Bountiful, Kentucky Wonder Wax Pole, Kentucky Wonder Wax Runner, Black Turtle Soup, Black Turtle 1, Black Turtle 2, Dubbele Witte, Widusa, and Saxa) were local lesions and systemic necrosis followed by death of the plant.

Arachis hypogaea Tainung No. 4, *P. vulgaris* cvs. Sanilac, Monroe, Pinto III reacted with local lesions only; and *Chenopodium quinoa* reacted with both local and systemic local lesions. Vein necrosis on the inoculated leaves was observed on *P. vulgaris* Sprite.

The following hosts were not infected with any of the three isolates: *G. max,* Kwanggyo, Shih-shih, AVRDC G-5, AGS147, Gun Tsuru, PI360835, *P. vulgaris* cvs. Great Northern 123, Immuna and Michelite 62, *Pisum sativum* cvs. Perfected Wales, and Dark-Skin Perfection, *Tetragonia expansa, Trifolium pratense* Kenland, *Trifolium repens, Vigna radiata* V2010, Oklahoma *V. unguiculata* Local White Pod Yard-long Variety, Dagupan Pangasinan Coll. No. 3.1, 4.1, 4.2, 4.3; *Cucumis melo* Known You, *Capsicum annuum,* Yolo Wonder, *Cucumis sativus* Chicago Pickling, *Datura stramonium* R. Fulton strain, *L. esculentum* Marglobe, Fukuja No. 2, *N. glutinosa, N. tabacum* Samsun, Xanthi, *Ocimium basilicum, Petunia hybrida* King Henry and *Physalis floridana.*

The reactions of the other hosts are shown in Table 27.

The results of the serological tests are shown in Table 28. The three isolates reacted identically, and a single precipitin line without spur was formed with BICMV-AS, AzMV-AS, and PN-AS. The strongest precipitin lines were formed with the homologous antiserum and with AzMV-AS. A weak precipitin line was formed with BICMV. No reaction was obtained with the antiserum to SMV and the antiserum to M4, the unknown mungbean isolate.

The results of seed transmission are shown in Table 29. Seed transmission in soybean ranged from 9 to 95% for isolate PN and from 6 to 23% for isolate PM. In cowpea it ranged from 6 to 43% for isolate PM.

Conclusion

Based on the results of the host range and serological tests, it is assumed that the unknown soybean virus isolates are neither SMV nor BCMV. Serological tests indicate that these virus isolates are closely related to AzMV and BICMV. Additional tests by ISEM are presently conducted to establish the exact identity.

Screening of Selected AGS Lines, AGS Parents, and Soybean Accessions for Resistance to an Unknown Soybean Virus

Introduction

Several virus isolates have been recovered from soybean in Taiwan which could not yet be exactly identified. Host range and serological tests suggest that these isolates may be blackeye cowpea mosaic virus (BICMV), or a very closely related virus, such as adzukibean

mosaic virus (AzMV). Surveys are presently undertaken to assess the distribution and prevalence of this virus on soybean in Taiwan. Because of the wide host range, which includes almost all commercially grown leguminous crops, and the seed-transmitted nature of this virus, it is considered a potentially serious pathogen that should be included in AVRDC's soybean improvement program. As an initial step, AGS lines were screened for resistance to the unknown virus, represented by isolates PN, PM, and 74.

Materials and Methods

Twelve AGS lines previously rated immune (AGS 9, 19, 103, 112, 115, 129, 147, 174, 185, 209) or resistant (AGS 214, 216) to SMV; and eight accessions (G605, G629, G1385, G2042, G2043, G2424, G8252, G38) used as parents of immune AGS lines were tested with the three unknown virus isolates, PM, PN, and 74.

In addition, 15 soybean accessions previously reported to be resistant to SMV strain 1 (Acc. 38, 260, 270, 288, 311, 358, 394, 452, 453, 519, 1051, 1096, 1300, 1601, 2042), and 42 AGS lines were tested (AGS 1 to 40, AGS 203, 218).

Table 27. Host reactions of three unknown soybean virus isolates.

	S-PM	S-PN	S-74
Arachis hypogaea			
Tainung 9	nLL/ –	nLL/M	nLL/ –
G. max			
HLS	– / –.	nLL/ –	nLL
PI341242	N/N,M	N/N,death	N/N,death
PI96983	N/N,M	N/N,death	N/N,death
PI324068	N/N,M	N/N,death	N/N,death
P. vulgaris			
Topcrop	nLL/ –	nLL/N,death	nLL/ –
Red Greenleaf C	cLL/ –	– / –	– / –
Red Greenleaf B	cLL/ –	– / –	– / –
Jubila	nLL/ –	nLL/ –	nLL/VN
Imp. Tendergreen	nLL/ –	nLL/VN,death	nLL/VN,death
Amanda		nLL/ – – / –	– / –
Vicia faba	nLL/ –	nLL/ –	– / –
Vigna angularis			
Shiroazuki 100	– / –	VN/VC	VN
V. radiatap			
V2773	I/cLL,M	– / –	– / –
V1111	– /M	– / –	– / –
V. unguiculata			
Local Green Pod Yard Long	– / –	– /M	I/M
Chenopodium amaranticolor	cLL/cLL	cLL/ –	cLL/ –
Medicago sativa			
Du Puits	– / –	cLL/M	– / –
Spinacea oleracea			
Bloomsdale Long Standing	– / –	cLL/cLL	– / –

Table 28. Reactions of PM, PN, and 74 to five antisera in double diffusion tests.[z]

Ag \ As	AzMV-AS	BICMV-AS	M4-AS	PN-AS	SMV-AS
PM	+ +	+	–	+ + +	–
PN	+ +	+	–	+ + +	–
74	+ +	+	–	+ + +	–
SMV	±	+	–	–	+

[z]Symbols: ± = weak reaction, + = strong reaction.

Table 29. Seed transmission of unknown soybean virus isolates PN and PM in some local soybean and cowpea cultivars.

Cultivar	Seed Transmission[z](%)	
	PN	PM
G. max		
TN3	41	21
TN4	37	23
HL1	50	NT
PALMETTO	9	6
RYUHYO	95	NT
RYOKKOH	NT	23
KAOHSIUNG NO. 9	41	NT
V. sesquipedalis		
CP10	NT	6
CP22	NT	12
CP44	NT	7
CP57	NT	76
CP72	NT	43

[z]NT not tested

Inocula were prepared by grinding one part fresh leaves of *G. max* TN4, infected with the respective isolate in three parts 0.M phosphate buffer pH 7.0. Thirty-five to 50 plants were inoculated and kept in the greenhouse for 10 to 20 days for symptom expression. Symptomless plants were checked by ELISA.

Results

The 10 AGS lines immune to SMV were also found immune to the three unknown virus isolates. The SMV-resistant AGS line (AGS216), however, was susceptible to all three unknown virus isolates. The reactions of the parents of the SMV-resistant AGS lines, except G8252 (which is resistant to SMV, but susceptible to the unknown virus), were similar to the unknown virus.

Among the 42 AGS lines (1 to 40, 203, 218) three (AGS 9, 19, and 218) were found with immunity to the PM isolate. The first two were also reported immune to SMV. Line 218, however, was susceptible to SMV.

All but one of 15 *G. max* accessions reported to be resistant or immune to SMV strain 1 were also found immune or resistant (having less than 10% infection rate) to the PN-isolate. One accession, G2021, was susceptible to this isolate.

Although most accessions or lines had resistance or immunity to both SMV and the unknown soybean virus, a few lines (AGS216, G8252, G2021) stood out which possessed resistance to SMV, but not to the unknown isolates. The above-mentioned lines will be rescreened and used for genetic studies.

Conclusion

These results suggest that there are at least two or possibly more resistance systems involved.

Survey for Soybean Mosaic Virus (SMV) and an Unknown Virus in Taiwan

Introduction

A survey was initiated in 1982 to recover naturally occurring SMV strains on soybean and use these in AVRDC's soybean improvement program. In 1983 another virus (soybean

isolate PN)was included in the survey. This virus was then tentatively named peanut mosaic virus because it reacted positively in serological tests to the antiserum of a virus isolated from peanut by the virologists of the Taiwan Agricultural Research Institute (TARI). It also reacted positively in ELISA to blackeye cowpea mosaic virus (BlCMV) and adzukibean mosaic virus (AzMV).

In the 1983 survey, which covered the major soybean-growing areas of central eastern and southern Taiwan, 115 samples were collected; and of these, four were infected with SMV and 12 with the unknown virus. This survey was continued in 1984 with the purpose of isolating more SMV strains and to determine the importance of the unknown virus.

Materials and Methods

A total of 458 soybean leaf samples showing typical virus symptoms were collected from eastern Taiwan (Hualien), northern Taiwan (Ilan), central Taiwan (Taichung), and southern Taiwan (Pingtung, Tainan). Virus detection was by ELISA using the SMV antiserum (ATCC) and the antiserum against the unknown virus (PN-isolate). The immunoglobulin and enzyme conjugate of both antisera were used on a dilution of 1:1000.

Results

Thirty-seven of 458 samples tested were found to be infected with SMV; and 26 were found to contain the unknown virus. Of these, four were doubly infected with both SMV and the unknown virus. Symptoms associated with SMV were mottle, mosaic, crinkle, and veinbanding. Symptoms associated with the unknown virus were similar: crinkle, mottle, mosaic, and blistering.

The combined results of the 1983 and 1984 survey (Table 30) indicate that the unknown virus occurs in all major soybean-growing areas and is almost as frequently found as SMV.

Conclusion

These results have prompted us to study this unknown virus in greater depth and to explore possible sources of resistance.

Table 30. Survey for SMV and the unknown virus (PN-isolate)[z]

Location	Total No. of Samples Collected	Samples Infected with	
		SMV	unknown virus
Central Taiwan	46	2	9
Eastern Taiwan	247	12	11
Southern Taiwan	235	17	5
Northern Taiwan	40	0	1
Total	568	31	26

[z]Combined 1983 and 1984 results.

Detecting Soybean Mosaic Virus Strains

Introduction

A survey of the major soybean-production areas in Taiwan was made with the purpose of detecting and isolating SMV strains. Because several genes are known to confer resistance on the different strains of SMV, it was hoped that several different strains could be recovered and used for resistance screening.

Most isolates recovered from previous surveys were SMV-G1; several other isolates could not be strain-typed. These and some other isolates recovered in a recent survey were strain-typed in 1984.

Materials and Methods

Ten SMV isolates were tested: S-121, S-220, S-223, S-226, S-227, S-233, S-245, S-246, S-260, S-261.

Fifteen plants each of the different soybean cultivars (Clark, Rampage, Davis, York, Marshall, Ogden, Kwanggyo, Buffalo) used by Cho and Goodman for SMV strain classification were inoculated with one part freshly infected leaves ground in 0.1M phosphate buffer pH 7.0. Symptomless plants were checked by ELISA.

Results

Six of the isolates were tested on eight of Goodman's differentials. Three of these (121, 223, 226) could not be identified, because they did not fit any of the strains in the Cho and Goodman's classification scheme. They reacted identically, infecting *G. max* cvs. Rampage, Clark, Davis, York, and Ogden by producing mosaic on these hosts. Isolate 227 was identified as SMV-1, because it only affected cvs. Clark and Rampage. Isolate 220 was tentatively classified as G-7, because this isolate was able to infect cv. Buffalo. According to Cho and Goodman's scheme, strain G-7 is the only strain which can infect Buffalo. However, Cho's strain 7 produced necrosis on this host and Kwanggyo. Our strain, however, differed slightly in that it developed necrosis only on Buffalo and mosaic on Kwanggyo. The failure of our strain to produce necrosis on Kwanggyo may be due to different growth conditions.

Isolate 233 is considered G-4, although it produced mosaic on Ogden and not necrosis, as Cho and Goodman's G-4. Four other isolates (245, 246, 260, 261) were so far only tested on Kwanggyo to determine whether they are strain 7 or not. None of them infected Kwanggyo, indicating that they were strains different from SMV G-7.

Detection of Seed-Transmitted SMV after Seed Storage

Introduction

In breeding for SMV resistance, the resistance of the plant to infection, the establishment of the virus or its strain, and low seed transmissibility are important. This is considered important when new strains of the virus arise for which the original resistance genes do not confer resistance.

For routine evaluation of low seed transmission, a reliable method of screening and rating must be first developed. For that purpose some preliminary tests were conducted.

Materials and Methods

Plants of soybean cultivar TN4 were inoculated with SMV-G1 at the primary leaf stage. After harvest, seeds were collected and stored in a paper bag in the cold room. At various intervals after harvest, both the germination and the virus infection rates were measured. Four hundred seeds were planted in a growth room at 26 °C. Virus infection was assessed visually. Symptomless plants were checked in batches of 20 by bioassay on *P. vulgaris* Topcrop.

Results

No statistically significant decrease of virus infection was noted at various storage times, although a trend towards a lower percentage was observed (Table 31). At the storage conditions

used in this experiment, the germination rate immediately after harvest was found significantly higher than that of the following sampling dates. However, no significant decrease in germination rate was detected from one month to nine months after harvest.

Conclusion

It appears that in variety TN4, SMV apparently does not get inactivated during storage of up to nine months. If this is generally true of SMV-infected soybean, seed transmission of SMV can be assayed after longer periods of storage.

Table 31. Seed transmission of SMV after different storage durations.

Time (after Harvest)	Virus Infection (%)	Germination (%)
1 day	8.7	98.1 a
1 month	7.5	93.1 b
4 months	7.3	94.0 b
5 months	6.1	95.0 b
6 months	5.3	95.0 b
7 months	5.9	92.2 b
8 months	5.6	94.0 b
9 months	5.9	93.6 b

Nutrition, Environment and Management

Agricultural Economics

Processing Tomato Production In Taiwan

Introduction

This study was aimed at understanding the problems and the economic significance of processing tomato production in Taiwan.

Materials And Methods

Processing tomato production is concentrated in Tainan, Chiayi, and Yunlin Counties. Yenshui, Tungshih, and Shuilin which are the biggest production townships in the above counties, were chosen for this study (Fig. 1). From the name lists supplied by the Farmers' Associations (FAs) and the representatives of the farmers, 39 farmers from Yenshui, 79 from Tungshih, and 59 from Shuilin were randomly selected and interviewed from May to July, 1984.

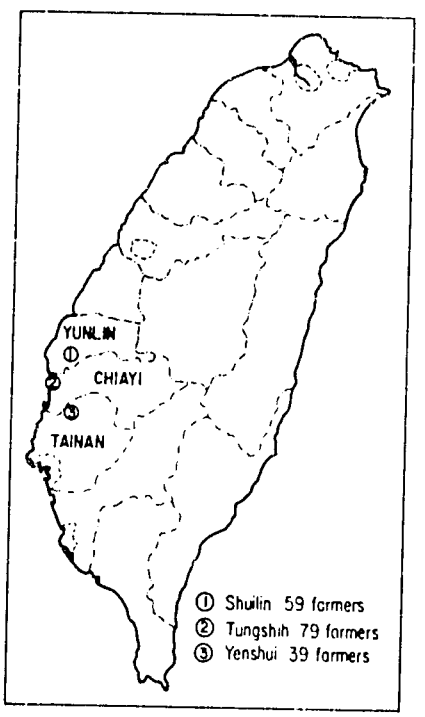


Fig. 1.
Sampling places in the survey of processing tomato production in Taiwan, 1984.

Results

Most farmers reported that their farm problem was temperature (Table 1). High temperature reportedly caused diseases and the delay in fruit setting. Some farmers attributed poor fruit-set rate and fruit defects to low temperature. On the average, each parcel of processing tomato had one to two different kinds of diseases and insects, most incidences of which were slight (Table 2).

The majority of the farmers did not decide the kind of processing tomato to plant (Table 3). They accepted whatever cultivar the farmers' representatives distributed. In most cases, each representative had more than one cultivar in his seedling nursery. From the farmers' viewpoint, the following were the ideal characteristics of processing tomato : large fruit size, very red color, high yield, labor-saving at harvest, nonperishability, resistance to diseases, and easy control of insects, among others (Table 4).

Table 1. Percentage of total parcels with the temperature problem in processing tomato, 1983 to 1984.

Township	Temperature Too High(%)	Temperature Too Low(%)
Yenshui	38	17
Tungsih	42	6
Shuilin	69	0

Table 2. Incidence of diseases and insects by township, 1983 to 1984.

Township	Diseases and Insects[z]	Diseases and Insects Reported to be Slight (%)
Yenshui	1.35	87
Tungshih	1.90	93
Shuilin	2.11	89

[z]Average number of kinds of diseases and insects in one parcel of processing tomato.

Table 3. Reasons for choosing the kind of processing tomato planted by township, 1983 to 1984.

Reason	Yenshui (%)	Tungshih(%)	Shuilin (%)
High yield	11	14	4
No choice, accepted what was distributed	57	55	69
Influence of neighbors	2	1	6
For intercropping	4	0	0
Large fruit size, labor-saving at harvest	4	5	1
Previous good experience with the cultivar	9	8	10
Ignorance of which cultivars were best	9	1	1
Good color	6	0	0
Short duration	2	0	0
Good cultivar	6	2	0
Less perishability	2	4	3
Free seeds	2	0	0
For trial	2	18	7
In demand at factory or market	0	2	3
Strong resistance to diseases	0	2	0
A case of mistaken seedling identity	0	1	0
Result of land consolidation	0	1	0
Heat tolerance	0	1	0

Most farmers were not satisfied with the contractual production system in the 1983-84 crop year (Tables 5). The major reasons were the inability to harvest part of the crop and the reported irregularities with regard to pricing, grading, weighing, of factories and representatives during an oversupply of the product (Table 6). Those who were satisfied with the contractual system mentioned stable price and guaranteed outlet as the main reasons.

The major crops competing with processing tomato were corn, sweet potato, peanut, and corn shoot (Tables 7, See p. 275). Farmers grew processing tomato mainly because it had a higher expected income and could better use family labor than the competing crops. It also diversified farming, and, thus, lessened risks.

Generally speaking, processing tomato production was profitable in the 1983-84 crop year. Farm income and net returns of the crop were positive in all three production townships, except the net returns in Shuilin Township (Tables 8 to 10).

Conclusion

The farmers considered processing tomato an important crop from the standpoint of management because it was profitable, had a higher expected income, made better use of family labor, diversified farming, and provided a guaranteed market outlet and stable income. Institutional malpractices could be reduced if the farmer were free to decide what type of processing tomato to grow in what season. A heat-tolerant tomato will solve the problem of high temperature and, hence, remove the constraint to the expansion of production seasons.

Table 4. The ideal characteristics of processing tomato by township, 1983-84.

Ideal Characteristic	Yenshui (%)	Tungshih (%)	Shuilin (%)
Large fruit size	66	24	18
Labor-saving at harvest	16	8	21
Very red, good color	53	21	0
High , stable yield	47	38	45
Heat tolerance	3	0	2
Short duration	11	3	2
Resistance to diseases and insects	32	21	4
Nonperishability	13	18	13
Can be harvested by machine	5	0	0
Less harvest frequency	3	1	0
Uniform color	3	0	0
Medium size	3	0	0
In demand	5	7	5
Resemblance to a particular cultivar	26	3	0
Frost, cold tolerance	0	4	0
No opinion	0	12	20
Vigorous growth	0	1	0
Juicy fruit	0	1	7
Salability at the fresh tomato market	0	3	18
Uniform maturity	0	3	0
Less branches for convenience in spraying and harvest	0	4	0

Table 5. Farmers' opinion by township regarding the contractual production system, 1983-84.

Township	Satisfied (%)	Not Satisfied (%)	Not Certain (%)
Yenshui	31	69	0
Tungshih	44	54	3
Shuilin	19	71	10

A less perishable cultivar is preferred because the farmer can store it longer in fields when there is an oversupply of the crop in the market. Finally, a cultivar with large fruits will save picking time.

Table 6. Reasons for farmers' dissatisfaction and satisfaction with the contractual production system by township, 1983-84.

Reasons for Dissatisfaction	Yenshui (%)	Tungshih (%)	Shuilin (%)
Part of the crop not harvested	56	80	86
Low price	52	2	10
Problems with grading and inspection	26	20	7
Profit shared with representatives	7	0	0
Delay in payment	4	0	5
Contract price not followed	15	5	7
Delay in shipment	0	7	0
Oversupply	0	2	2
Problems with weighing	0	5	5
Unmarketed small tomatoes	0	2	0
Freight payment for collecting crates from FA	0	2	0
Inability to get crates from FA due to distance	0	2	0
Promised sorghum seeds not given by FA	0	2	0
No document of contract	0	0	2
Nonpayment	0	0	2
Dishonest representatives	0	0	2
Payment through representatives	0	0	2
Marketing through representatives	0	0	2
Faking of contractual acreage for profit by representatives	0	0	2
No opinion	0	2	0
Reasons for Satisfaction			
Guaranteed outlet, stable income,convenient shipment, contract compliance	38	33	43
Satisfied, but marketed volume be increased	25	36	29
Satisfied, but the price be improved	13	6	0
Fair price	12	6	14
No delay in payment	12	0	0
Satisfied, but grading be improved	0	3	0
Satisfied, but small tomato be marketed	0	6	0
Good weighing system	0	3	0
Easy marketing procedure	0	3	0
Satisfied, but shipping be made convenient	0	3	0
Dependable negotiations with factories by FA	0	6	0
No opinion	0	0	14

Table 8. Production budget per hectare for processing tomato in Yenshui township, 1983 to 1984.

Quantity marketed (kg)	65,770			
Average price (NT$/kg)	1.59			
Gross returns (NT$)	104,691			
Farm income (NT$)[z]	54,301			
Net returns (NT$)[y]	13,072			
Production Cost (NT$)	**Noncash**	**Cash**	**Total**	**% Total Cost**
Seedlings	0	4,286	4,286	4.68
Inorganic fertilizer	0	11,947	11,947	13.04
Organic fertilizer	0	294	294	0.32
Pesticide and herbicide	0	8 195	8,195	8.94
Fuel, water fee	0	689	689	0.75
Labor	39,652	21,392	61,044	66.63
Animal power	954	1,241	2,195	2.40
Machine power	623	2,346	2,969	3.24
Total	41,229	50,390	91,619	100.00

[z]Gross returns minus cash production cost. [y]Gross returns minus total production cost.

Table 7. Reasons for growing processing tomato instead of competing crops in Yenshui, Tungshih, and Shuilin Townships, 1983 to 1984.

Reason for Growing Processing Tomato	Competing Crops							
	Yenshui		Tungshi		Shuilin			
	corn (%)	sweet potato (%)	corn (%)	peanut (%)	corn (%)	corn shoot (%)	sweet potato (%)	peanut (%)
Higher expected income than competing crops	32	57	41	22	26	30	38	7
Recommendation by farmers' representatives	19	14	12	17	13	0	6	7
For intercropping with other crops	3	0	0	0	10	0	6	7
Custom	13	0	1	0	10	5	6	7
Neighbors' influence	3	0	0	6	29	15	31	60
Corn seeds not available	3	0	4	0	0	0	0	0
Free tomato seeds	3	0	0	0	0	0	0	0
For rotation	10	14	1	0	0	0	0	0
Soil too infertile for corn	10	0	10	0	0	0	0	0
For trial	6	0	9	11	0	5	0	0
Suitable soil for tomato	3	0	0	0	0	0	6	0
Insufficient water source	3	0	0	0	0	0	0	0
For crop diversification	3	0	16	17	23	25	6	0
Labor intensiveness of sweet potato	0	14	0	0	0	0	0	0
Riskiness of sweet potato in the rainy season	0	14	0	0	0	0	0	0
Labor intensiveness of corn	0	0	1	0	0	0	0	0
Malpractices in corn price policy	0	0	3	0	0	0	0	0
Inability of corn to absorb family labor	0	0	9	0	0	0	0	0
Result of soil consolidation	0	0	1	0	0	0	0	0
Serious insect incidence in corn	0	0	1	0	0	0	0	0
More fertilizer needed for corn	0	0	1	0	3	0	0	0
High labor needs and wages for peanut in the rainy season	0	0	0	17	0	0	0	0
Riskiness of peanut in the rainy season	0	0	0	22	0	0	0	0
Unsuitable soil for peanut	0	0	0	6	0	0	0	0
Labor-intensiveness of the competing crop	0	0	0	0	3	35	0	7
No experience with corn shoot	0	0	0	0	0	5	0	0
Expensive peanut seeds	0	0	0	0	0	0	0	7

Table 9. Production budget per hectare for processing tomato in Tungshih Township, 1983 to 1984.

Quantity marketed (kg)	63,597			
Average price (NT$/kg)	1.72			
Gross returns (NT$)	109,301			
Farm income (NT$)[z]	56,020			
Net returns (NT$)[y]	969			
Production Cost (NT$)	Noncash	Cash	Total	% Total Cost
Seedlings	0	3,078	3,078	2.84
Inorganic fertilizer	0	9,676	9,676	8.93
Organic fertilizer	438	3,138	3,576	3.30
Pesticide and herbicide	0	9,401	9,401	8.68
Fuel, water fee	0	2,511	2,511	2.32
Labor	53,322	21,825	75,147	69.37
Animal power	1,111	1,274	2,385	2.20
Machine power	180	2,378	2,558	2.36
Total	55,051	53,281	108,332	100.00

[z]Gross returns minus cash production cost. [y]Gross returns minus total production cost.

Table 10. Production budget per hectare for processing tomato in Shuilin Township, 1983 to 1984.

Quantity marketed (kg)	59,076			
Average price (NT$/kg)	1.71			
Gross returns (NT$)	100,862			
Farm income (NT$)[z]	30,036			
Net returns (NT$)[y]	-22,154			
Production Cost (NT$)	Noncash	Cash	Total	% Total Cost
Seedlings	0	3,626	3,626	2.95
Inorganic fertilizer	0	9,500	9,500	7.72
Organic fertilizer	1,196	1,332	2,528	2.05
Pesticide and herbicide	0	9,039	9,039	7.35
Fuel, water fee	0	3,291	3,291	2.68
Labor	50,154	39,543	89,697	72.91
Animal power	570	1,606	2,176	1.77
Machine power	270	2,889	3,159	2.57
Total	52,190	70,826	123,016	100.00

[z]Gross returns minus cash production cost. [y]Gross returns minus total production cost.

Farmers' Responses to Two Processing Tomatoes

Introduction

A new tomato cultivar Tainan Selection NO. 2 (TS2) was developed at AVRDC and was released by the Tainan District Agriculture Improvement Station (DAIS) in 1982. This research was conducted to assess the crop's performance in the farmers'fields and its acceptance by the farmers. TK70, which is one of the major processing tomato cultivars in Taiwan, was included for comparison in this study.

Materials And Methods

In 1983, Tainan DAIS introduced TS2 to the Tungshih and Shuilin townships. Information needed for this study was taken from previous research. Many farmers adopted more than one processing tomato cultivar simultaneously. On the average, 24 to 36% of the total tomato parcels surveyed in Tungshih were planted to TS2 and TK70, respectively. In Shuilin, every 44% of the total tomato parcels surveyed was devoted to the cultivars.

Results

In Tungshih, the number of kinds of diseases and insects reportedly occurring in a tomato parcel was significantly less for TS2 than for TK70 at the 10% level of significance (Table 11). In Shuilin, the number of kinds of diseases and insects was significantly more for TS2 than for TK70 at the 5% level of significance. However, the proportion of kinds of diseases and insects which were reportedly severe was not significantly different between TK70 and TS2 in both townships (Table 12).

Table 11. Average number of kind of diseases and insects in a tomato parcel in Tungshih and Shuilin by cultivar, 1983 to 1984.

Cultivar	Tungshih	Shuilin
Tainan Selection No. 2	1.68	2.30
TK70	1.98	1.84

Table 12. Percentage of severe disease and insect infestation on Taiwan Selection No. 2 in Tungshih and Shuilin, 1983 to 1984.

Cultivar	Tungshih(%)	Shuilin(%)
Tainan Selection No. 2	2.13	11.76
TK70	6.02	8.82

High temperature was a problem of TK70 in both townships. In Shuilin, high temperature was also a problem of TS2 but not as much in Tungshih. As a result of a delay in planting, much fewer farmers in Tungshih reported that high temperature was a problem of TS2. Moreover, some parcels of TS2 in Tungshih were severely affected by cold temperature (Table 13). The planting seasons of TS2 and TK70 in Tungshih and Shuilin are shown in Table 14. Apparently, planting seasons affected the yield. TS2 and TK70 yielded much more when planted before October than when planted after this month, especially in Tungshih where some farmers planted TS2 very late in the year (Table 15).

Table 13. Percentage of total parcels of processing tomato affected by high temperature in Tungshih and Shuilin Townships by cultivar, 1983 – 84.

Cultivar	Tungshih		Shuilin	
	too high (%)	too low (%)	too high (%)	too low (%)
Tainan Selection No. 2	29	14	78	0
TK70	64	0	66	0

Table 16 shows the estimated yields and volume percentages of the two cultivars in Tungshih and Shuilin. The volume percentages of TS2 and TK70 were similar in Tungshih, but higher in TS2 than in TK70 in Shuilin, indicating a stronger demand for the former. There was not much difference in yield between the two cultivars in Tungshih; however, in Shuilin, TK70 was much more productive. Processing tomato was more productive in Shuilin, unfortunately the oversupply was not absorbed by the factories. The volume percentage was lower in Shuilin than in Tungshih.

The advantages and disadvantages of the two cultivars are shown in Tables 17 to 18, respectively. Farmers in Tungshih favored TK70, but those in Shuilin preferred TS2. In Tungshih, the farmers who thought the cultivar they planted did not have any advantages or were not sure of its advantages, were less for TK70 than for TS2. Likewise, in Tungshih, more TK 70 farmers thought their cultivars did not have any disadvantages. In Shuilin, although nearly the same percentage of farmers thought both cultivars did not have any disadvantages, a considerably higher percentage of the farmers gave positive responses for TS2 than for TK70. The farmers' attitude towards the two cultivars were also reflected in their responses to the superiority of TS2 (Table 19) and their plans (Table 20). In Tungshih, the majority of the farmers thought TS2 was not superior, but the reverse was true in Shuilin. Therefore, farmers in Shuilin were more interested in continuing with TS2 than in Tungshih.

Table 14. Percentage of land parcels planted in different seasons in Tungshih and Shuilin, 1983-84.

Planting	Season	Tungshih (%)		Shuilin (%)	
		Tainan Selection No. 2	TK70	Tainan Selection No. 2	TK70
July	early	0	0	0	0
	mid	0	0	0	0
	late	0	0	2.94	0
August	early	0	0	8.82	0
	mid	4.35	8.33	8.82	15.00
	late	0	8.33	14.71	30.00
September	early	30.43	54.17	8.82	15.00
	mid	13.04	12.50	20.59	15.00
	late	8.70	8.33	14.71	20.00
October	early	17.39	0	11.76	5.00
	mid	17.39	4.17	5.88	0
	late	4.35	4.17	2.94	0
November	early	4.35	0	0	0

Table 15. Yields of Tainan Selection No. 2 in Tungshih and Shuilin Townships by season, 1983 to 1984.

Planting Season	Tungshih (kg/ha)	Shuilin (kg/ha)
Before Oct. (Oct. excluded)	75,502	77,757
After Oct. (Oct. included)	41,145	65,951

Table 16. Estimated yields and percentages of marketed processing tomato in Tungshih and Shuilin Townships by cultivar, 1983 to 1984.

Cultivar	Tungshih		Shuilin	
	Yield (kg/ha)	Marketed (%)	Yield (kg/ha)	Marketed (%)
Tainan Selection No. 2	60,602	89	76,938	77
TK70	69,205	90	88,420	69

TS2 was commended because it was less perishable, had satisfactory yield in Tungshih and Shuilin, and was in demand at the Shuilin fresh market. TK70 was cited for its high yield, large fruits, and labor-saving advantage at harvest in both townships.

The major common disadvantage of TS2 in both townships was the slow development of its color. Due to environmental factors, farmers planting TS2 also reported low yield and high seasonal deviation in yield in Tungshih, and fruit rotting in Shuilin. TK70's perishability was cited as its major disadvantage in both townships. Diseases and insects in Tungshih and low yield in Shuilin were also mentioned as the negating factors of TK70.

Conclusion

In general, TS2 did not show stronger resistance to diseases and insects in farmers' fields than TK70. The average yield of TS2 was lower than that of TK70. Season was an important factor to the yield of TS2, especially in Tungshih where some tomato crops were planted very late in the year. High temperature was a problem of both cultivars and depended largely on which seasons the crops were planted.

TS2 was better accepted in Shuilin because it was less perishable, had satisfactory yield, and had better market outlets. As a result, more farmers planned to continue growing it than TK70 in this township.

Table 17. Advantages of processing tomato in Tungshih and Shuilin Townships by cultivar, 1983 to 1984.

Advantage	Tungshih		Shuilin	
	Tainan Selection No. 2 (%)	TK70 (%)	Tainan Selection No. 2 (%)	TK70 (%)
Size of large fruits (big)	8	21	8	23
High yield, satisfactory yield	20	41	61	26
Less perishablility	33	0	22	6
Good shape	8	0	0	0
Good color	0	7	0	6
Ease in picking the fruit	4	0	8	0
Desirability in factories	8	0	3	0
Ease in spraying (branches not spread apart)	4	0	0	0
Early maturity	0	3	0	0
Heat tolerance	4	0	3	0
Labor-saving at harvest	4	14	6	10
Ease in spraying, walking around, and shipping	4	7	0	0
Easy management	4	3	6	3
Heavy fruits	0	7	0	6
Less harvest frequency	4	0	0	0
Juicy, good for tomato paste	0	7	0	3
High fruit-set rate	0	3	0	0
Frequent harvests that absorb family labor	0	3	0	0
Stable yield	0	3	0	0
No advantages, unsure of advantages	33	24	8	42
Easy control of diseases and insects	0	0	3	0
Fast growth	0	0	0	3
Good taste	0	0	3	3
Salability at the fresh market	0	0	39	0

Table 18. Disadvantages of processing tomato in Tungshih and Shuilin Townships by cultivar, 1983 to 1984.

Disadvantage	Tungshih		Shuilin	
	Tainan Selection No. 2 (%)	TK70 (%)	Tainan Selection No. 2 (%)	TK70 (%)
Thinness of skin, perishability, tendency to rot	0	21	14	13
Difficulty in removing fruit stem when dry	9	0	6	0
Diseases and insects	9	18	8	7
Low yield	22	0	3	10
Difficulty in picking fruits	4	0	0	0
Longer time for fruit to redden	14	0	11	0
Undesirability in factories	0	4	0	0
Difficulty in harvesting & spraying (too branchy)	0	4	0	7
Susceptibility to low temperature	4	0	0	0
Labor-consuming	0	7	0	0
Poor fruit-set rate due to low temperature	9	0	0	0
High seasonal deviation in yield	13	0	0	0
Uncertainty in planting season	4	0	0	0
Small fruit at late harvest	4	0	0	0
Poor early fruit setting	0	4	0	0
Necessity for many replantings	0	4	0	0
No disadvantages, unsure of disadvantages	17	43	42	43
Small fruit	0	0	3	3
Undesirable red color	0	0	6	0
Impurity of seeds	0	0	3	3
Poor fruit-set rate	0	0	3	3
Unacceptability in the fresh market	0	0	0	3
Lack of experience	0	0	0	3
Long harvest period	0	0	3	0
Susceptibility to high temperature	0	0	3	0
Lack of juiciness	0	0	6	0
Oversupply	0	0	3	0
Need for more fertilizer	0	0	3	0
Susceptibility to flooding	0	0	3	0

Table 19. The superiority of Tainan Selection No. 2 from the farmers' viewpoint.

Superiority	Tungshih (%)	Shuilin (%)
Superior	35	40
Not superior	65	27
Not sure of superiority	0	33

Table 20. Farmers' plans for growing the same cultivars in the 1984 to 1985 crop year.

Plan	Tungshih		Shuilin	
	Tainan Selection No. 2 (%)	TK70 (%)	Tainan Selection No. 2 (%)	TK70 (%)
Continue growing	39	39	59	2[illegible]
Not continue growing	26	19	21	36
Not certain	35	42	20	39

Responses of Factories to a New Tomato Cultivar

Introduction

This study was conducted to understand the processing quality of an AVRDC new tomato cultivar-Tainan Selection No.2 (TS2), in order to determine its expansion, and the need for suitable cultivars to control seasonal supply better.

Materials and Methods

This study was based on the information collected from 21 factories through telephone interviews in October, 1984. According to Taiwan Exports of Canned Food, 32 factories exported tomato products in 1982. However, the factories that stopped producing tomato products were not cooperative, and so, were not interviewed together with those having unlisted telephone numbers.

Results

Most of the factories interviewed produced peeled whole tomato, sliced tomato, and tomato paste. Some produced assorted vegetables, tomato puree, catsup, and tomato juice (Table 21). TS2 was adopted by many factories and was favored by most of them for such concentrated products as peeled whole tomato, sliced tomato, and assorted vegetables. Firmness, ease of peeling, good shape, and satisfactory color contributed most to its good processing quality (Table 22). The major reported disadvantages of TS2 included unsatisfactory fruit color at late harvest, unsatisfactory flesh color after peeling, infected fruit top, and low conversion rate for tomato paste.

Most factories using TS2 decreased its contractual area in the 1984-85 crop year (Table 23) mainly because of the small production share of tomato products in the factory, and an oversupply in the USA (Table 24). However, a number of factories still increased their TS2 contractual area because of its good processing quality and multiple uses for peeled whole tomato, sliced tomato, and tomato paste (Table 25).

To level off the supply of tomato and its demand for labor from peak time to the slack season, most factories need cultivars which can be harvested as early as in November and December and as late as in April and May (Tables 26, 27, 28).

Table 21. Processed tomato products, products using Tainan Selection No. 2 (TS2), and factories partial to TS2.

Tomato Product	Factories Producing a Particular Tomato Product (%)	Factories Using TS2 for a Particular Tomato Product (%)	Factories Ranking TS2 as One of the Best Cultivars for a Particular Tomato Product (%)
Peeled whole tomato	86	33	100
Sliced tomato	71	60	78
Assorted vegetables	19	50	100
Tomato paste	62	15	0
Tomato puree	19	0	0
Catsup	10	0	0
Tomato juice	24	20	0

Conclusion

Forty-eight percent of the factories interviewed processed TS2. The new cultivar was acceptable by most canners of peeled whole tomato, sliced tomato, and assorted vegetables

Table 22. Advantages and disadvantages of Tainan Selection No. 2 by type of tomato product.

Advantage	Whole Tomato (%)	Sliced Tomato (%)	Assorted Vegetables (%)
No change in shape, no canning damage	20	0	0
Firmness	20	100	100
Ease in peeling	60	33	100
Satisfactory color	40	17	0
Even fruit size	20	0	0
Small fruit stem	20	0	0
Good shape	20	0	0
Fewer seeds than other cultivars	0	33	0
Disadvantage			
Unsatisfactory color at late harvest	33	50	33
Unsatisfactory color after peeling	67	0	0
Blackish spots on the fruit top	0	100	0
Unsatisfactory yield	0	50	0
Uneven fruit size	0	50	0
Low conversion rate	0	0	33
Not very red color	0	0	33

Table 23. Changes in the contractual area of Tainan Selection No.2 between the crop years 1983-84 and 1984-85.

Change In Area	Percentage of the Factories
Had never contracted the crop	52
Increase in acreage	19
Decrease in acreage	29

Table 24. Reasons for reducing the contractual area of Tainan Selection No.2.

Reason	Percentage
Reduction of tomato products	17
Blackish spots on the fruit top	17
Unsatisfactory yield	17
Unavailable seeds	17
Trouble with contract-breaking	17
Less need for tomato in the factory	33
Oversupply in the USA	33

Table 25. Reasons for increasing the contractual area of Tainan Selection No. 2.

Reason	Percentage
Firmness	25
For trial purposes	25
Mutiple uses (whole tomato, sliced tomato, and tomato paste)	75
Good color	25

because of its firm flesh, ease of peeling, good shape, small stem, and fewer seeds. An improvement in fruit color and resistance to diseases of the fruit top would enhance its processing quality.

TS2 had a low conversion rate and an unsatisfactory color for tomato paste, which was one of the major tomato products in Taiwan. Therefore, breeding more cultivars to meet this market demand would better benefit factories, and hence, the farmers. The expansion of TS2 largely depends on such economic factors as the supply of processing tomato outside Taiwan, the economic share of tomato processing in the factory, and a reasonable solution to the competition for the new cultivar between factories and fresh markets.

Most factories need a more balanced distribution of their production outputs thoughout the seasons by extending the harvest season to November and December. Therefore, the development of better heat-tolerant cultivars would facilitate factory scheduling of tomato production for an efficient efficient control of seasonal supply.

Table 26. The extension of tomato harvest seasons needed by factories in Taiwan.

Opinion	Harvest Seasons	
	forward extension (%)	backward extension (%)
Yes	75	30
No	15	55
Not sure	10	15

Table 27. Reasons for the need of extending the harvest seasons.

Reason	Forward Extension (%)	Backward Extension (%)
Disperse the peak time	60	67
Deliver tomato products early	7	0
Adjust storage	7	0
Minimize conflict with other products	7	0
Distribute labor well	13	0
Provide business for slack season	27	33
Try it	0	17

Table 28. Extended harvest seasons needed by factories in Taiwan.

Extended	Season	Forward Extension (%)	Backward Extension (%)
August	(late)	7	0
November	(early)	27	0
	(mid)	7	0
	(late)	33	0
December	(early)	13	0
	(mid)	13	0
April	(late)	0	25
May	(mid)	0	50
	(late)	0	25

The Responsibility and Financial Position of Tomato Farmers' Representatives in Taiwan

Introduction

Farmers, factories, and farmers' representatives are all interrelated in the tomato enterprise. In addition to the study o. tomato production from farmers' and factories' viewpoints, a study of the role and the financial position of farmers' representatives would better identify the importance of tomato production in the rural community.

Materials and Methods

From the lists submitted by the Farmers' Associations (FAs), 21 representatives were interviewed in Yenshui, Tungshih, and Shuilin Townships, from May to July, 1984.

Results

Representatives of Yenshui and Shuilin Townships were all tomato farmers selected by the factories. In Tungshih Township, however, the FA and tomato farmers were the representatives. The representative's most important work was to cultivate and sell tomato seedlings, and to assist in postharvest handling. In most cases, the representative had free seeds from the factory with whom he signed a contract for the farmers. In the 1983-84 crop year, the net returns and farm income for a seedling nursery of 0.1 ha was NT$8,312 and NT$14,363, respectively. The average nursery size was 0.178 ha (Tables 29 and 30).

Postharvest handling includes distribution of crates, inspection, weighing, shipment, and forwarding of tomato income to the farmers. On the average, each representative received from the factory NT$116,916 for his services (Table 31).

Conclusion

The representative was quite active in the rural community for the role he played in the tomato contractual production system. His major work was to cultivate tomato seedlings and to assist in postharvest handling, for which he had received a substantial sum in the 1983-84 crop year.

Table 29. Costs and returns of producing tomato seedlings in a 0.1 ha nursery, 1983-84.

No. of seedlings (plants)	134,520.00			
Price (NT$/plant)	0.15			
Gross returns (NT$)	20,178.00			
Farm income (NT$)[z]	14,363.00			
Net returns (NT$)[y]	8,312.00			
Production Cost (NT$)	Noncash	Cash	Total	Total Cost(%)
Material	463	2,040	2,503	21.09
Labor	5,541	3,376	8,917	75.15
Animal power	21	115	136	1.15
Machine power	26	284	310	2.61
Total	6,051	5,815	11,866	100.00

[z]Gross returns minus cash production cost. [y]Gross returns minus total production cost.

Table 30. The represrntative's earnings from seedling cultivation.

Item		Income (NT$)
Net returns per 0.1 ha	(NT$)	8,312.00
Farm income per 0.1 ha	(NT$)	14,363.00
Average nursery size	(Ha)	0.178
Total net returns	(NT$)	14,795.00
Total farm income	(NTS)	25,566.00

Table 31. The representative's earning from the postharvest handling service.

Item	Income (NT$)
Per ton of tomato delivered (NT$)	65.00
Average tonnage delivered (Tons)	1798.70
Total commission (NT$)	116,916.00

Farmers' Viewpoint on the Production of Summer Chinese Cabbage in the Lowlands of Taiwan

Introduction

The agroeconomic factors in the production of AVRDC and Chang-puh Chinese cabbage were studied in this research work.

Materials and Methods

Interviewed in October 1984 were 28 farmers of AVRDC Chinese cabbage and 24 Chang-puh farmers (Fig. 2). Fourteen farmers of AVRDC Chinese cabbage were from Minghsiung Township and 14 from Hsinkong Township, both of which were the biggest production areas of AVRDC Chinese cabbage in Taiwan. Ten of the 24 Chang-puh farmers were from Hsinkong ; the rest were from Erhling. The sample included almost all the farmers growing AVRDC and Chang-puh Chinese cabbage in these three townships.

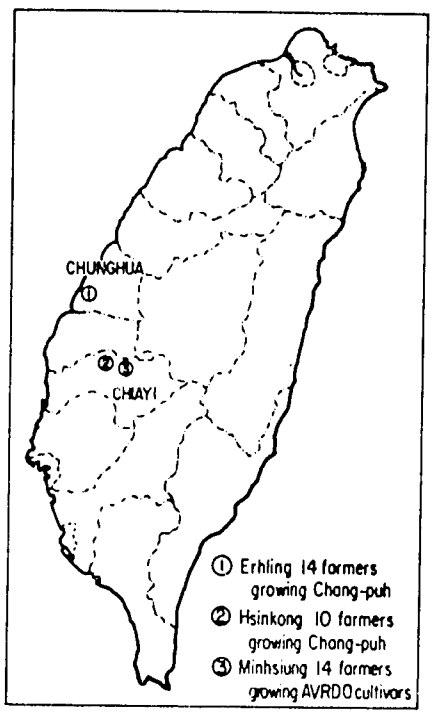


Fig. 2.
Sampling places in the survey of Chinese cabbage production in South Central Taiwan, 1984.

Results

Soft rot and rotting seemed to be more severe in AVRDC Chinese cabbage than in Chang-puh. They were the most serious diseases reported by the farmers (Table 32). Most farmers were motivated by FA extension work or the local demonstrations in their first planting of AVRDC Chinese cabbage. Many of them, however, did not plan to grow the same cultivar in the next year mainly because of low price and diseases. However, the majority of Chang-puh farmers planned to continue with the cultivar because of its superiority and high price (Tables 33 to 36).

From the farmers' viewpoint, the ideal characteristics for summer Chinese cabbage were its good appearance, high yield, strong demand, resistance to diseases, and heat tolerance (Table 37). The production of Chang-puh appeared to be more profitable than that of AVRDC

Chinese cabbage in 1984. On the average, the volume of transaction per hectare was 14 t for AVRDC Chinese cabbage at NT$5.61/kg and 15 t for Chang-puh at NT$7.16/kg (Table 38).

Conclusion

Chang-puh appeared to be better accepted by farmers than the AVRDC Chinese cabbage for its stronger market demand. Appearance was considered the most important factor in the price difference. In 1984, soft rot and rotting were the most severe diseases in the production of summer Chinese cabbage in the lowlands of Taiwan.

Table 32. Incidence of insects and diseases in summer Chinese cabbage, 1984.

Insects and Diseases	AVRDC (N = 28)		Chang-puh (N = 24)	
	severe (%)	light (%)	severe (%)	light (%)
Soft rot, rotting	41	17	17	33
Mildew, spot	7	14	4	25
Darkened inner leaves	7	0	0	0
Rotten outer leaves	3	0	0	0
Shrunken leaves	0	0	0	4
Diamondback moth	10	55	4	50
Army worm	14	55	0	4
Imported cabbage worm	10	17	4	58
Cabbage webworm	0	3	0	0
Striped beetle	3	0	0	12
Black cutworm	0	3	0	38
Cabbage looper	0	0	0	8

Table 33. Reasons for choosing the type of summer Chinese cabbage, 1984.

Reason	AVRDC (N = 28) (%)	Chang-puh (N = 24) (%)
FA extension (first trial)	76	0
AVRDC or local demonstrations	10	0
Recommendation by seed dealers of neighbors	7	17
Custom, good experience with the cultivar	3	33
Free or cheap seeds	0	12
Satisfactory yield	0	17
Large and heavy heads	0	8
White leaves	3	0
Freedom from shrunken leaves	3	0
Short growth duration	3	4
High head-formation rate	0	4
Strong resistance to diseases	0	4
High germination rate	0	4
Heat tolerance	3	8
Good appearance (tight, smooth, round)	3	8
Guaranteed price	3	0
High price, popularity in markets	0	29

Table 34. Farmers' plans for growing the same type of summer Chinese cabbage in 1985.

Farmers' Plan	AVRDC Farmers (N = 28) (%)	Chang-puh Farmers (N = 24) (%)
Continue growing	10	67
Not continue growing	69	8
Not certain	21	25

Table 35. Reasons for farmers' decision about growing the same type of summer Chinese cabbage in 1985.

Reason	AVRDC (N = 3) (%)	Chang-puh (N = 16) (%)
Satisfactory yield	33	25
Ease in management	33	0
Large, heavy head	0	12
Short growth duration	0	6
Good cultivar	0	31
Flood tolerance	0	6
Freedom from varietal variation	0	6
Appearance	33	6
Good taste	33	6
High price, popularity in markets	33	38
For another trial	33	0
Custom	0	6
Diversification	0	6

Table 36. Reasons for farmers' decision about not growing the same type of summer Chinese cabbage in 1985.

Reason	AVRDC (N = 20) (%)	Chang-puh (N = 2) (%)
Appearance	10	0
Loose leaves (easily shred in transportation)	15	0
Head crack	5	0
Greenish leaves	10	0
Horizontal darkened cracks on midribs	5	0
Rotting at maturity (should be harvested before maturity)	15	0
Spots	5	0
Diseases and insects	20	0
Low yield	5	0
Labor intensiveness	0	50
Change of cultivar	10	0
Change in choice to a competing crop	0	50
Expensive seeds	5	0
Low price, nonpopularity in markets	55	0
Unprofitable cultivar	5	0

Table 37. Ideal characteristics of summer Chinese cabbage.

Characteristics	Farmers (N = 52) (%)	Characteristics	Farmers (N = 52) (%)
Resistance to diseases	21	Large and heavy heads	9
Resistance to insects	11	White leaves	2
Freedom from rotting	8	No varietal deviations	6
Spotlessness	2	High head-formation rate	4
Ease in management	6	More inner leaves	2
Heat tolerance	17	Uniform growth duration	2
Flood tolerance	9	Good taste	2
High yield	28	High price	28
Good appearance	51	Popularity in markets	21
Fine fiber	2	Not sure, no opinions	4
Short growth duration	6		

Table 38. Costs and returns of producing summer Chinese cabbage per 1984.[z]

Returns	AVRDC Chinese cabbage	Chang-puh
Quantity sold (kg)	14,429	15,484
Yield (kg)	15,090	15,643
Average price (NT$/kg)	5.61	7.16
Gross returns (NT$)	80,982	110,900
Farm income (NT$)[y]	20,443	50,361
Net returns (NT$)[x]	-51,615	-22,196

Production Costs (NT$)	Noncash[w]		Cash		Total		Total Cost(%)	
	AVRDC	C-P	AVRDC	C-P	AVRDC	C-P	AVRDC	C-P
Seeds, seedlings	0	157	5948	6062	5948	6219	4.36	4.67
Inorganic fertilizer	0	0	12377	15152	12377	15152	9.08	11.38
Organic fertilizer	507	517	1716	3232	2223	3749	1.63	2.82
Pesticide and herbicide	0	0	10787	16232	10787	16232	7.91	12.20
Fuel, water fee	0	0	874	881	874	881	0.64	0.66
Plastic for mulching	0	0	6485	0	6485	0	4.76	0
Rice straw, rice husk	1324	1618	77	0	1401	1618	1.03	1.22
Crates	0	0	3908	2110	3908	2110	2.87	1.59
Other materials	0	0	61	18	61	18	0.04	0.01
Labor	69166	69799	7571	7230	76737	77029	56.29	57.87
Animal power	369	161	320	391	689	552	0.51	0.41
Machine power	692	305	1527	1572	2219	1877	1.63	1.41
Transportation	0	0	8863	5427	8863	5427	6.50	4.80
Commission, market users's fee	0	0	3751	2232	3751	2232	2.75	1.68
Total	72058	72557	64265	60539	136323	133096	100.00	100.00

[z]AVRDC Chinese cabbage and Chang-puh. [y]Gross returns minus cash production cost. [x]Gross returns minus total production cost. [w]C-P = Chang-puh.

Prices of Selected Types of Summer Chinese Cabbage

Introduction

Because price discrimination was reported to be a major hindrance to the adoption of AVRDC Chinese cabbage by farmers, there is a need to investigate more thoroughly the seasonal price changes of AVRDC and Chang-puh Chinese cabbages.

Materials and Methods

Farmers' Associations (FAs) of Minhsiung and Hsinkong Townships in Chiayi County were requested to record every single transaction of their AVRDC and Chang-puh Chinese cabbages from August to November, 1984. The crops were sold at the Taipei Agricultural Products Marketing Company through the FA cooperative marketing. Daily prices and transaction volumes of various types of summer Chinese cabbage were also recorded by the computer system of the Company. Under the computer system, AVRDC Chinese cabbage included those cultivars which had a similar appearance to the cultivar developed at AVRDC.

Results

In Minhsiung and Hsinkong, AVRDC Chinese cabbage seemed to have more favorable average prices than its counterpart in September (Fig. 3). The reverse was true in October and November. Viewed nationwide, however, the prices of Chang-puh were higher than those of AVRDC Chinese cabbage at the Taipei Agricultural Products Marketing Company (Fig. 4).

The maximum price also concerned farmers as much as the average price. In September, in most dates, AVRDC Chinese cabbage had a maximum price equal to or higher than Chang-puh. However, in October and November, Chang-puh had a higher maximum price nearly every day (Table 39). Regression analysis showed that the price of AVRDC Chinese cabbage was affected not only by its own supply but also by the total transaction volume of Chinese cabbage at the market.

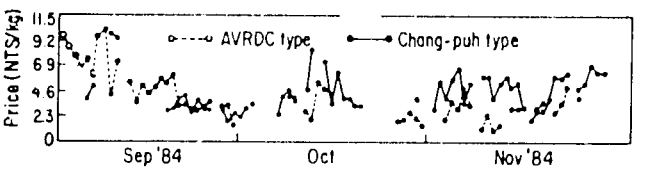


Fig. 3.
Daily prices of Chinese cabbage from Minhsiung and Hsinkong Townships as recorded at the Taipei Agricultural Products Marketing Company, September to November 1984.

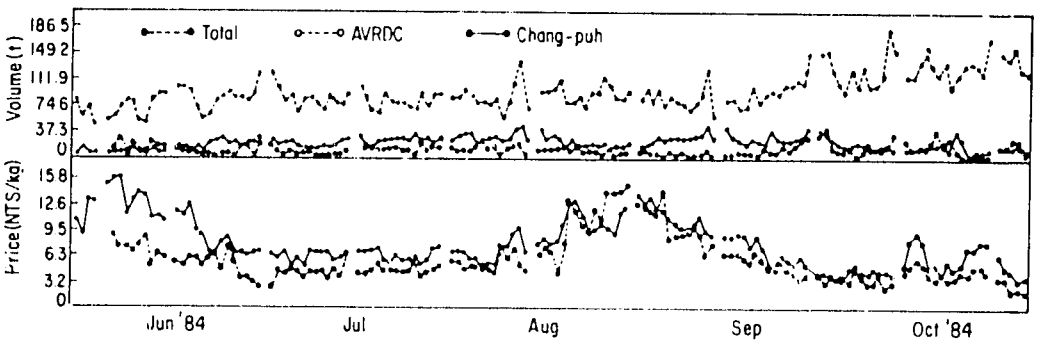


Fig. 4. Daily prices and transaction volume of Chinese cabbage at the Taipei Agricultural Products Marketing Company, June to October 1984.

Table 39. Chinese cabbage (x) with higher or equal maximum price at the Taipei Agricultural Products Marketing Company for Minhsiung and Hsinkong Townships from Sept. 6 to Nov. 26, 1984[z].

Dates	AVRDC	Chang-puh	Dates	AVRDC	Chang-puh
9- 6	x		10-15		x
9- 7	x		10-16		x
9-10		x	10-30		x
9-11		x	11- 4		x
9-15	x		11- 5		x
9-18	x		11- 6		x
9-19	x		11- 7	x	
9-20	x		11- 8		x
9-21	x		11-10		x
9-22	x		11-11		x
9-23	x	x	11-12		x
9-24	x	x	11-13		x
9-25		x	11-15		x
9-26	x	x	11-16		x
9-28	x		11-19	x	x
9-29	x		11-20		x
9-30	x	x	11-22		x
10- 9		x	11-23		x
10-10		x	11-24		x
10-12		x	11-26		x
10-13		x			

[z]"x" represents the cultivar which had a maximum price equal to or higher than that of the other on the specific date indicated.

Conclusion

The price analysis based on FA daily record-keeping further verified the information gathered from producers in Minhsiung and Hsinkong that the AVRDC Chinese cabbage was less competitive than Chang-puh at the market. The point is even stressed further when the information on daily price and transaction volume at the Taipei Agricultural Products Marketing Company was applied to the study.

It would not be advisable to market AVRDC Chinese cabbage after late September when the total supply of Chinese cabbage goes up rapidly. In other words, it will be financially risky for farmers to grow the crop after late July. The increase in supply of other types of Chinese cabbage would have a negative effect on the prices of AVRDC Chinese cabbage even though its supply is not increased.

Causes of Price Differentiation between Two Selected Types of Chinese Cabbage

Introduction

The weaker demand for AVRDC Chinese cabbage was reported by the producers in Minhsiung and Hsinkong Townships and also verified by the study on the prices of Chinese cabbage. This paper aimed to find out the reasons for the price discrimination between AVRDC and Chang-puh Chinese cabbages.

Materials and Methods

Because it was very hard to locate consumers who experienced both AVRDC and Chang-puh Chinese cabbages, it was then decided that interviews with retailers and wholesalers should replace consumer interviews.

From 57 vegetable retail markets in Taipei City, 14 were randomly selected. Ten or the actual number of Chinese cabbage retailers, whichever is the smaller, were interviewed at each selected market in October, 1984. The sample size was 85 which was 78% of the total number of Chinese cabbage retailers at the 14 retail markets. About two-thirds of the Chinese cabbage wholesalers at the Taipei Agricultural Products Marketing Company were interviewed in September, 1984. The sample size was 40.

Results

There were 14% of wholesalers and 22% of retailers who were selling AVRDC Chinese cabbage when interviewed. The majority reported that they had purchased this commodity before, but stopped doing so because of its negative characteristics. They purchased this commodity only when the market was short of Chinese cabbage (Table 40). The major disadvantages of the cultivar were reportedly its taste, unfavorable and untidy appearance, abundant fiber, and tendency to rot. The wholesalers emphasized diseases more often than retailers because the commodity was always well trimmed at the wholesale market before it was sold to retailers (Table 41).

Many sellers could not give any advantages of the commodity probably because its disadvantages outweighed the advantages. Those who did, mentioned lower price and good taste as the two major advantages of the AVRDC cabbage. The cabbage was also considered as a good substitute for Chang-puh when its supply was low at the market (Table 42).

Conclusion

Theoretically, the market reflects the consumers' preference. Sellers tell only the consumers' choices. Therefore, it was certain that AVRDC Chinese cabbage was less popular

than Chang-puh in Taipei City, although the consumer was not interviewed. This paper, however, did not actually identify the reasons for this disfavor by the consumer. In fact, the seller could only guess why the consumer preferred Chang-puh to AVRDC Chinese cabbage. In this research, the seller guessed that most consumers did not buy AVRDC Chinese cabbage because of its taste and appearance, among many other reasons.

In the retail market, the displayed AVRDC Chinese cabbage appeared less presentable than Chang-puh because of its loose and stale look. Chang-puh stayed fresh and firm for a longer period of time.

Table 40. Experience status of retailers and wholesalers of AVRDC Chinese cabbage, 1984.

Experience	Retailers (N = 85) (%)	Wholesalers (N = 40) (%)
Is selling the commodity	11	10
Sold it before	53	65
Not sure	11	0
No experience	26	25

Table 41. Disadvantages of AVRDC Chinese cabbage.

Disadvantages	Retailers (N = 64) (%)	Wholesalers (N = 39) (%)
Appearance	47	54
Taste	56	54
Fiber	25	5
Counterfeit	3	0
Fleshy, wrinkled leaves	<1	3
Not fresh, not clean, spotty looks	16	21
Inner rotten leaves	6	0
Expensive	<1	0
Inconvenience of loose leaves	<1	0
Too small	<1	0
horizontal darkened cracks on leaves	0	10
Rotten	0	21
No opinion	0	5

Table 42. Advantages of AVRDC Chinese cabbage.

Advantages	Retailers (N = 22) (%)	Wholesalers (N = 34) (%)
Drought tolerance	5	0
Ease in management	0	3
High yield	0	3
Ease in taking leaves apart	9	0
Fiber	5	0
Large size	5	3
Less rotten leaves	5	0
Taste	41	3
Appearance	0	3
Cheaper price	36	3
Good substitute for Chang-puh	9	15
No opinion	0	24
No advantage	0	29

Shopping Behavior of Chinese Cabbage Consumers

Introduction

This study was conducted to understand the reasons for the consumers' choice of Chinese cabbage and to determine the uses of various Chinese cabbage in summer. In this paper. Chinese cabbage was classified into lowland and highland Chinese cabbage. Both AVRDC and Chang-puh Chinese cabbages are lowland types.

Materials and Methods

Yung-chih Supermarket belonging to the Taipei Agricultural Products Marketing Company was chosen for this study. Chinese cabbage was packed in plastic bags. Lowland and highland Chinese cabbages were displayed separately on two neighboring stands of the vegetable aisle in the supermarket. Interviews were conducted on four holidays of two consecutive weeks in early September 1984. Nearly all consumers who purchased Chinese cabbage were interviewed. The analysis based on 280 consumers could reflect the shopping behavior of an above-average consumer in the summer.

Results

Of the Chinese cabbage consumers, 60% and 40% bought lowland and highland types, respectively. Table 43 shows why consumers preferred a certain type of Chinese cabbage. Such reasons as taste, recipe consideration, and tidy appearance applied to both cabbages. Many consumers also pointed out that they bought highland cabbage due to custom.

In the summer season, Chinese cabbage was popularly sauteed (Table 44). Lowland Chinese cabbage was commended by most consumers because it was tasty when sauteed.

Table 43. Reasons for consumers' choice for a type of Chinese cabbage in summer, 1984.

Reason	Lowland (N = 165) (%)	Highland (N = 112) (%)
Fresh and clean appearance	16	25
Low price	0	4
Taste	44	19
Size	4	6
Greenish color	2	0
Shape	5	6
Tight and heavy head	1	
Less fiber	2	0
For trial purposes	7	2
Custom	4	21
Adaptability to a specific food preparation	32	22
Mother's advice	1	0
Good food taste when sauteed	11	3
No opinion, no idea	7	7
Less midribs	5	2
Crispiness for pickle	1	0
For a change	2	6
Ease in washing	1	1
For dumplings	0	1
Large and mature appearance	0	1
Thick midribs	1	0
Ease in taking leaves apart	0	2

However, many consumers still bought highland Chinese cabbage for sauteing mainly because of custom and sometimes because lowland Chinese cabbage was untidy in appearance. The second popular kitchen use of Chinese cabbage was boiling. Highland Chinese cabbage was cited as the better type for this particular recipe.

Most shoppers were female (Table 45). Female shoppers obviously knew about the characteristics of Chinese cabbage better than male shoppers. The latter's ignorance in their choice of a certain Chinese cabbage attested to this. Most female shoppers chose Chinese cabbage according to taste, recipe, and freshness.

Conclusion

Taste, recipe, and freshness were the main reasons for the consumer's choice for a certain Chinese cabbage. The most important kitchen use of Chinese cabbage in the summer was sauteing. Lowland Chinese cabbage was favored because it tasted good when sauteed. The second popular use of Chinese cabbage was boiling. Highland Chinese cabbage was the major source for this particular recipe. Most shoppers were female. They were much more certain about the reasons for their preference of a certain Chinese cabbage than the male shoppers.

Table 44. Uses of summer Chinese cabbage according to the consumers, 1984.

Use	Lowland (N = 102) (%)	Highland (N = 81) (%)	Total (N = 183) (%)
Sauteed	79	52	67
Boiled	17	44	29
Steamed	2	5	3
Raw	3	4	3
Stewed	0	5	2
Mixed	1	0	1
Deep fried	0	1	1

Table 45. Reasons for choosing a type of Chinese cabbage by sex, 1984.

Reasons	Female (N = 245) (%)	Male (N = 32) (%)
Fresh and clean appearance	19	22
Low price	2	0
Taste	36	16
Size	5	3
Greenish color	1	0
Shape	5	6
Tight and heavy head	1	0
Less fiber	1	0
For trial purposes	5	3
Custom	11	16
Adaptability to a specific food preparation	31	6
Mother's advice	1	0
Good food taste when sauteed	9	0
No opinion, no idea	3	34
Less midribs	4	0
Crispiness for pickle	1	0
For a change	4	3
Ease in washing	1	3
For dumplings	1	0
Large and mature appearance	0	3
Thick midribs	1	0
Ease in taking leaves apart	1	0

Crop Management

Effect of Time of Leaf-tying and Daminozide on Summer Chinese Cabbage

Introduction

It is difficult to produce headed Chinese cabbage in the lowland tropics and subtropics in summer, unless heat-tolerant (tolerant to mean temperatures above 25°C) hybrids are cultivated. Our previous research revealed that moderately heat-tolerant varieties can form firm heads in summer by tying the outer leaves. This summer we continued to screen new cultivars for adaptability to leaf-tying and to evaluate the effect of daminozide (growth-retarding chemical) on head formation and yield of Chinese cabbage.

Materials and Methods

For the leaf-tying study, a split-plot design was used with three replications. The main plot included six cultivars: ASVEG 1, Ping-Luh, Fong-Luh, Wen-Wu, Thai A, and Thai B. The subplot treatment was the time of leaf-tying, i.e., at 25, 30, 35, and 40 days after transplanting (DAT) (Table 1). The seedlings (35 days old) were transplanted on July 11 and harvested on August 24, and 29.

For the leaf-tying and chemical spray study, a split-plot design was used with three replications. The main plot consisted of two cultivars: Ping-Luh and Fong-Luh. The subplot treatments comprised the control; leaf-tying at 30 DAT; 2000 and 4000 ppm daminozide spray at 20, 25, and 30 DAT (Table 2). The seedlings (32 days old) were transplanted on July 10 and harvested on August 24, and 29.

Table 1. Treatments in experiment 1.

Main Plot: Cultivar	Subplot: Leaf-Tying Time
ASVEG 1	Control (none)
Ping-Luh	Leaf-tying at 25 DAT[z]
Fong-Luh	Leaf-tying at 30 DAT
Wen-Wu	Leaf-tying at 35 DAT
Thai A	Leaf-tying at 40 DAT
Thai B	

[z]DAT = days after transplanting.

Table 2. Treatments in experiment 2.

Main Plot: Cultivar	Subplot: Leaf-Tying and Chemical Spray
Ping-Luh	Control (none)
Fong-Luh	Leaf-tying at 30 DAT[z]
	Daminozide 2000 ppm at 20, 25, and 30 DAT
	Daminozide 4000 ppm at 20, 25, and 30 DAT

[z]DAT = days after transplanting.

Results

Leaf-tying study. The temperature during the course of the investigation ranged from 22.4° to 33.4°C. The precipitation was 472 mm. Since this experiment was not mulched, a heavy rain (110 mm) at one week after transplanting crushed the seedlings and killed some plants.

Leaf-tying increased the heading rate by at least 27% for all the cultivars, except ASVEG 1 and Thai A (heat tolerant) (Table 3). Heading rate was not significantly affected by the time after transplanting of the leaf-tying. The leaf-tying treatment accompanied by increased heading rate resulted in yields either higher or significantly higher than that of the control. The optimum time of leaf-tying for most cultivars ranged between 35 and 40 DAT (Table 4). However, leaf-tying should not be done before 35 days for Fong-Luh, whereas Wen-Wu should not be leaf-tied later than 35 DAT.

The vegetative growth of all the cultivars was damaged seriously by heavy rain. Flood-susceptible cultivar Fong-Luh (0.403% fiber content/fresh weight) showed a much poorer response to early leaf-tying (before 35 DAT) than Ping-Luh (0.477% fiber content/fresh weight).

Leaf-tying and chemical spray study. In this experiment, the seedlings were transplanted one day earlier (July 10) and harvested on the same day as the leaf-tying experiment. Leaf-tying and daminozide treatments significantly increased heading rate over that of the control for Ping-Luh but not for Fong-Luh (Table 5). There were no significant differences in head weight among treatments for Ping-Luh, but the leaf-tying treatment developed the lowest head weight among the treatments for Fong-Luh. The highest marketable yield for Ping-Luh was achieved in the leaf-tying treatment, whereas none of the treatments significantly increased yield for Fong-Luh.

Conclusion

In a summer Chinese cabbage trial, heading rate was significantly increased by leaf-tying for all cultivars, except for the heat-tolerant ones. The optimum time for leaf-tying ranged

Table 3. Effect of leaf-tying time on heading rate of summer Chinese cabbage, 1984.[z]

Leaf-Tying (DAT)[y]	Heading Rate (%)[x]					
	ASVEG #1	Ping-Luh	Fong-Luh	Wen-Wu	Thai A	Thai B
Control	66.7 b	36.3 b	29.6 b	30.0 b	71.6 a	44.7 b
25	91.7 ab	66.3 a	65.0 a	69.1 a	89.7 a	74.7 a
30	82.4 ab	87.7 a	57.1 a	87.6 a	90.4 a	77.1 a
35	96.1 a	91.2 a	70.0 a	92.7 a	98.3 a	100.0 a
40	89.5 ab	87.4 a	81.1 a	66.9 a	85.8 a	86.4 a

[z]Transplanted on July 11 and harvested on August 24, 29. [y]DAT = days after transplanting. [x]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT)

Table 4. Effect of leaf-tying time on marketable yield of summer Chinese cabbage, 1984.

Leaf-Tying (DAT)[z]	Marketable Yield (t/ha)[y]					
	ASVEG #1	Ping-Luh	Fong-Luh	Wen-Wu	Thai A	Thai B
Control	5.94 a	3.70 c	2.56 b	3.67 b	6.64 a	4.18 b
25	6.05 a	4.76 bc	4.84 b	4.30 b	5.80 a	5.03 ab
30	6.53 a	7.35 ab	4.24 b	5.56 ab	6.67 a	5.52 ab
35	7.29 a	8.38 a	4.83 b	7.86 a	6.84 a	7.80 a
40	7.84 a	8.05 a	8.20 a	4.63 b	6.39 a	6.65 ab

[z]DAT = days after transplanting. [y]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).

between 35 to 40 DAT. Daminozide application (2000 and 4000 ppm) and leaf-tying at 30 DAT increased heading rate of Ping-Luh greatly, but not of Fong-Luh.

Table 5. Effect of leaf-tying time and daminozide on heading rate, head weight, and marketable yield of summer Chinese cabbage, 1984.[z]

Treatment	Heading Rate (%)[y]		Head Weight (g/head)[y]		Marketable Yield (t/ha)[y]	
	Ping-Luh	Fong-Luh	Ping-Luh	Fong-Luh	Ping-Luh	Fong-Luh
Control	44.9 b	80.6 a	373 a	520 ab	4.4 a	11.1 ab
Leaf-tying at 30 DAT	98.2 a	97.6 a	387 a	387 c	10.1 a	10.2 b
Daminozide 2000 ppm	73.9 a	90.9 a	367 a	580 a	7.5 ab	14.0 a
Daminozide 4000 ppm	81.0 a	86.9 a	303 a	443 bc	6.6 b	10.1 b

[z]Transplanted on July 10 and harvested on August 24 and 29. [y]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).

Herbicide Screening for Transplanted Chinese Cabbage

Introduction

The commonly used grass herbicides for Chinese cabbage are not effective. Four new postemergence grass herbicides were, therefore, included in the trials this year.

Materials and Methods

The experiments were conducted in spring, summer, and fall of 1984. Individual plots were 3×6 m for spring, and 1.5×6×2 m (bed) for summer and fall. Cultivar ASVEG 1 was planted in the summer trial and cultivar Ping-Luh, in the spring and fall. The herbicides tested were Nitralin, DCPA, Stomp, Furore, Illoxan, Onecide, and Nabu. These were tested either alone or in combination with Stomp. Experiments were arranged in a randomized complete block design with four replications. Herbicides were sprayed either preemergence (pre) or postemergence (post).

Results

In the spring trial, the results are shown in Table 6. Grasses were controlled significantly by all the herbicide treatments. Stomp and DCPA showed better control of broadleaf weeds than the other herbicides. Broadleaf pressure in this trial was not greatly different from that in an ordinary year. Nitralin controlled broadleaf weeds moderately, caused some crop injury, and resulted in yield loss. Furore, Illoxan, Onecide, and Nabu did not control broadleaf weeds. No herbicide treatment yielded significantly lower than the weed-free check.

Results of the summer trial are shown in Table 7. Phytotoxicity of 1.5 kg a.i./ha furore was serious in the early growing stage. Furore and Illoxan, at the rates of 0.5 and 1.08, kg a.i./ha, respectively, damaged the plants negligibly. None of the treatments yielded as well as the weed-free check, although yields of five treatments were not significantly lower. Yields were depressed because none of the treatments adequately controlled broadleaf weeds. In addition, grassy weeds were poorly controlled by Stomp, Illoxan, Nabu, and Onecide at 0.175 kg a.i./ha.

Results of the autumn trial are summarized in Table 8. Infestation of both grasses and broadleaf weeds was extremely low. Furore and Illoxan exerted severe phytotoxicity one and two weeks after postemergence application. Only Furore at 1.5, and Illoxan at 0.72 and 1.08 kg a.i./ha produced significantly lower yields than the weed-free check.

Table 6. Chinese cabbage yield and fresh weight of weeds as affected by herbicide application, AVRDC, spring 1984.[z]

Herbicide		Rate & Application Method[y] (kg a.i./ha)	Yield (t/ha)	Weed Weight at Harvest (t/ha) grass[x]	nutsedge[w]	broadleaf[v]
Weedy check			11.87	13.75 a	0 c	2.73 cde
Weed-free check			14.93	0 b	0 c	0 e
Nitralin	0.75	Pre	12.55	0 b	1.88 a	1.08 cde
Stomp	1.00	Pre	17.44	0 b	0.92 abc	0.08 e
DCPA	7.50	Pre	16.73	1.38 b	0.45 bc	0.23 de
Furore	0.50	Post 17 DAT	14.79	0 b	0.49 bc	4.69 bc
Furore	1.00	Post 17 DAT	16.33	0 b	0.54 bc	7.85 ab
Furore	1.50	Post 17 DAT	17.53	0 b	1.16 ab	4.29 bc
Illoxan	0.72	Post 17 DAT	16.97	1.24 b	1.18 ab	4.51 bc
Illoxan	0.90	Post 17 DAT	15.88	0 b	0.32 bc	2.84 cde
Illoxan	1.08	Post 17 DAT	15.60	0 b	0.73 bc	1.45 cde
Onecide	0.175	Post 17 DAT	17.37	0.68 b	0.98 abc	3.72 cde
Onecide	0.35	Post 17 DAT	15.25	0 b	0.28 bc	4.12 bcd
Onecide	0.45	Post 17 DAT	12.11	0 b	0.81 bc	4.86 bc
Nabu	0.2	Post 17 DAT	16.71	1.70 b	0.41 bc	3.84 cde
Nabu	0.3	Post 17 DAT	16.96	0 b	0.27 bc	4.61 bc
Nabu	0.4	Post 17 DAT	14.42	0 b	0.58 bc	10.30 a
LSD 5%			4.58			

[z]Cultivar Ping-Luh: seed sown on February 24, transplanted on March 20, and harvested on May 14. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT). [y]Applied preemergence (March 20) and postemergence to weeds (April 6-17 DAT). [x]*Eleusine indica* and *Echinochloa colonum*. [w]*Cyperus rotundus*. [v]*Portulaca oleracea*, *Chenopodium album* and *Amaranthus* spp.

Table 7. Chinese cabbage yield, phytotoxicity, and fresh weight of weeds as affected by herbicide application, AVRDC, summer 1984.[z]

Herbicide	Rate & Application Method[y] (kg a.i./ha)	Crop Yield (t/ha)	Crop Injury at 1 WAPA[x]	Weed Weight at Harvest (t/ha) grass[w]	broadleaf[v]
Weedy check		1.71 g	0 d	33.70 a	1.10 gh
Weed-free check		20.83 a	0 d	0	0 d h
Stomp	1.0	11.81 bcde	0 d	17.58 b	1.54 fgh
Furore	0.5	9.08 bcdef	12 b	0 d	10.11 ab
Furore	1.5	6.25 efg	92 a	0 d	13.09 a
Furore + Stomp	0.5 + 1	15.48 ab	8 bc	4.73 d	2.00 fgh
Furore + Stomp	1.5 + 1	9.55 bcdef	90 a	0 d	4.32 defg
Illoxan	0.72	6.55 efg	0 d	13.13 bc	5.41 cdef
Illoxan	1.08	3.74 fg	5 bcd	13.63 bc	10.14 ab
Illoxan + Stomp	0.72 + 1	8.03 cdefg	0 d	6.83 cd	1.04 gh
Illoxan + Stomp	1.08 + 1	14.80 abc	0 d	0 d	2.18 efgh
Onecide	0.175	7.89 defg	0 d	14.33 bc	5.41 cdef
Onecide	0.525	9.47 bcdef	0 d	0 d	8.84 bc
Onecide + Stomp	0.175 + 1	14.29 abcd	0 d	3.25 d	1.37 fgh
Onecide + Stomp	0.525 + 1	15.23 ab	3 cd	2.10 d	4.14 defg
Nabu	0.2	4.16 fg	0 d	1.45 d	6.16 cde
Nabu	0.4	8.91 bcdef	0 d	3.45 d	7.92 bcd
Nabu + Stomp	0.2 + 1	10.40 bcdef	0 d	0 d	4.07 defg
Nabu + Stomp	0.4 + 1	14.94 ab	0 d	2.20 d	3.97 defgh

[z]Cultivar ASVEG No. 1: seeds sown on June 1, transplanted on June 30, and harvested on August 15-17. Means within a column followed by the same letter are not significantly different at the 5% level Duncan's Multiple Range Test (DMRT). [y]Applied preemergence to weeds (June 30). For treatments 4 to 19, all chemicals were applied postemergence at the fourth grass leaf stage, except Stomp which was applied preemergence. [x]WAPA: week after postemergence application. [w]*Echinochloa colonum*, *Eleusine indica* and *Cynodon dactylon*. [v]*Portulaca oleracea*, *Amaranthus* spp., *Eclipta prostrata*, and *Solanum nigrum*.

Table 8. Chinese cabbage yield and fresh weight of weeds as affected by herbicide application, AVRDC, fall 1984.[z]

Herbicide	Rate & Application Method[y] (kg a.i./ha)	Yield (t/ha)	Crop Injury at 1 WAPA[x] (%)	Weed Weight at Harvest (t/ha)	
				grass[w]	broadleaf[v]
Weedy check		21.06 ab	0 c	3.31 a	2.81 bcd
Weed-free check		22.37 a	0 c	0 c	0 d
Stomp	1.0	21.47 ab	0 c	0.45 c	0.11 d
Furore	0.5	20.04 abc	75 b	0 c	9.99 a
Furore	1.5	12.41 d	100 a	0 c	8.80 ab
Furore + Stomp	0.5 + 1	19.22 abc	74 b	0 c	0.03 d
Furore + Stomp	1.5 + 1	12.25 d	100 a	0 c	0.15 d
Illoxan	0.72	15.77 cd	99 a	1.40 b	8.56 ab
Illoxan	1.08	13.86 d	100 a	0 c	4.70 abcd
Illoxan + Stomp	0.72 + 1	16.77 bcd	98 a	0 c	0.08 d
Illoxan + Stomp	1.08 + 1	15.49 cd	100 a	0 c	0.07 d
Onecide	0.175	22.06 a	0 c	0 c	6.79 abc
Onecide	0.525	20.54 ab	0 c	0 c	4.10 abcd
Onecide + Stomp	0.175 + 1	18.87 abc	0 c	0 c	1.07 cd
Onecide + Stomp	0.525 + 1	19.67 abc	0 c	0.10 c	0.03 d
Nabu	0.2	19.48 abc	0 c	0 c	6.13 abcd
Nabu	0.4	20.62 ab	0 c	0 c	6.95 abc
Nabu + Stomp	0.2 + 1	21.67 a	0 c	0 c	0.38 d
Nabu + Stomp	0.4 + 1	22.39 a	0 c	0 c	0.48 d

[z]Cultivar, Ping-Luh: Seeds sown on Sept. 19, transplanted on Oct. 16, and harvested on Nov. 29, Dec. 3, 7, 11. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test(DMRT). [y]Stomp was applied preemergence to weeds (Oct. 16). For treatments 4 to 19, all other chemicals were applied postemergence at the four-leaf grass stage. [x]WAPA: 1 week after postemergence application. [w]*Digitaria* spp., *Echinochloa colonum, Eleusine indica*. [v]*Amaranthus* spp., *Chenopodium album, Solanum nigrum, Protulaca oleracea*.

Conclusion

Furore and Illoxan produced serious phytotoxicity in Chinese cabbage during the dry season, and their residual effects lasted two to three weeks; therefore, Furore and Illoxan should not be used in the dry season. Furore, Onecide, and Nabu generally controlled grass weeds, but not broadleaf weeds, in all seasons. Illoxan provided poor grass and broadleaf control. The combination of Furore, Illoxan, Onecide, and Nabu with Stomp increased the control of broadleaf weeds, however. In the Chinese cabbage summer trial, all the combined treatments with Stomp yielded better than those applied alone.

Damage due to weed infestation can be minimized with healthy seedlings and a quick establishment of plant canopy. So in summer, strong and well-nourished seedlings should be transplanted to the field, to enable them to compete with weeds in the initial growth stage.

Herbicide Screening for Transplanted Tomato

Introduction

Metribuzin is generally considered to be the most effective herbicide for both grass and broadleaf weed control in spring and autumn tomato. However, with heavy or successive rainfall, Metribuzin is easily washed away; and the grasses grow again to compete with tomato for nutrients and light at the later growth stages.

Four postemergence grass killers (Furore, Illoxan, Onecide, and Nabu) were applied alone or in combination with Metribuzin in the spring and summer in an attempt to find more effective tomato grass control for tomato.

Materials and Methods

Two experiments were conducted in spring and summer to find the most effective herbicide combination for transplanted tomato. A randomized complete block design with four and three replications for the spring and summer trials, respectively, was used.

Tainan No. 2 was transplanted on March 2, and AVRDC breeding line CL5915-153 (G) D 4-3-2 was planted on July 3. The spring trial consisted of three rows of tomato on a 3.6×6 m flat bed with a spacing of 1.2 m between rows and 0.4 m between plants. Plots were separated by 0.5 m furrows and 1.5 m walkways. The summer trial consisted of single rows of 15 tomato plants 40 cm apart on 1×6 m raised beds. Plots were separate by one skipped bed, by 0.5 m furrows, and by 1.5 m walkways. Water was supplied by furrow irrigation. Herbicides were sprayed either preemergence or postemergence. Details of each experiment are shown in Tables 9 and 10.

Results

Spring trial. Metribuzin applied postemergence at 19 DAT inflicted serious injury on tomato plants. The ratios of injured plants to total plants were 98, 99, and 44% at one, two, and four weeks after application, respectively. Applied postemergence at 11 DAT, Metribuzin resulted in moderate damage to tomato plants, and as the time passed the extent of the damage decreased to 10, 9, and 2% at one, two, and four weeks after application. The other herbicides did not injure the plants. Metribuzin controlled broadleaf weeds regardless of the time of its application, and grasses at 19 DAT.

The highest tomato yield (21.4 t/ha) was obtained with the preemergence application of Metribuzin (Table 9). Although Furore, Illoxan, Onecide, and Nabu resulted in significant grass control, the tomato yields obtained were much lower than that of the weed-free check. This was because these herbicides could not control broadleaf weeds sufficiently.

Table 9. Tomato yield and fresh weight of weeds as affected by herbicide application, AVRDC, spring 1984[z]

Herbicide	Rate & Application Method[y] (kg a.i./ha)		Total Fruit Yield	Fresh Weight of Weeds (t/ha)	
				grass[x]	broadleaf[w]
Weedy check			5.2 d	15.00 b	10.44 ab
Weed-free check			17.9 a	0 c	0 b
Metribuzin	0.75	Pre	21.4 a	24.30 a	0.63 b
Metribuzin	0.75	Post 19 DAT	12.5 bc	3.78 c	0.17 b
Furore	0.50	Post 19 DAT	8.4 cd	0 c	22.98 a
Furore	1.00	Post 19 DAT	8.0 cd	0 c	25.13 a
Furore	1.50	Post 19 DAT	8.6 cd	0 c	28.69 a
Illoxan	0.72	Post 19 DAT	6.6 d	1.30 c	26.24 a
Illoxan	0.90	Post 19 DAT	4.9 d	0.45 c	22.17 a
Illoxan	1.08	Post 19 DAT	4.5 d	0.10 c	25.75 a
Onecide	0.175	Post 19 DAT	5.4 d	0.38 c	22.87 a
Onecide	0.35	Post 19 DAT	5.2 d	0 c	28.76 a
Onecide	0.45	Post 19 DAT	5.1 d	0 c	19.23 a
Nabu	0.2	Post 19 DAT	4.3 d	0 c	17.18 ab
Nabu	0.3	Post 19 DAT	7.1 cd	0 c	19.98 a
Nabu	0.4	Post 19 DAT	5.9 d	0 c	28.30 a
Metribuzin	0.75	Post 11 DAT	17.4 ab	8.25 bc	0 b

[z]Transplanted on March 2 and harvested on May 7, 16, and 25. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test(DMRT). [y]Applied preemergence (March 2) and postemergence to weeds (March 21, 19 DAT). For treatments 4 to 16, all chemicals were applied postemergence 19 days after transplanting at the fourth leaf stage of grass weeds. [x]*Eleusine indica, Echinochloa colonum, Parpalum distichum, Digitaria* spp. [w]*Amaranthus* spp., *Chenopodium album, solanum nigrum, Portulaca oleracea.*

Summer trial. Heavy rain (65 mm) occurred three hours after the application of Metribuzin as preemergence herbicide. During the 76-day growing period, the precipitation was 741 mm. The low yield in this trial was attributed to heavy rain damage to the young plants, the death of plants, and the washing away of herbicides applied, which resulted in moderate to high weed pressure.

Tomatoes were moderately injured by Metribuzin applied postemergence at 10 days after transplanting and by Onecide (0.525 kg a.i./ha) plus Metribuzin at preemergence, and negligibly or erratically by Illoxan and Nabu (data not presented). All treatments yielded significantly lower than the weed-free check (Table 10).

Conclusion

In spring tomato, broadleaf weeds should be controlled to obtain high yield. Four grass killers effectively suppressed grass growth, but had no effect on broadleaf weeds; hence, they should be used together with Metribuzin which worked well on the latter. For the rainy summer season, herbicides tolerant to erosion and leaching should be used, since heavy and successive rainfall washes away the herbicides, brings about weed growth again, and results in yield loss. Future research is needed on herbicide stability in the rainy season.

Effect of Spacing on Growth and Yield of Tomato

Introduction

Tainan No. 2 was the first tomato variety released to Taiwan farmers from AVRDC. Farmers adopted narrower spacing than the recommended AVRDC cultural practice. The purpose of this project was to determine the best plant spacing for this tomato cultivar.

Table 10. Tomato yield and fresh weight of weeds as affected by herbicide application, AVRDC, summer 1984.[z]

Herbicide, Rate (kg a.i./ha) and Application Method[y]	Total Fruit Yield	Weight of Weeds (t/ha)		
		Grass[x]	Nutsedge[w]	Broadleaf[v]
Weedy check	0.32 c	22.13 ab	0 f	0 c
Weed-free check	5.75 a	0 f	0 f	0 c
Metribuzin 0.75 (Pre)	1.57 bc	21.23 ab	0.87 ef	0 c
Metribuzin 0.75 (Post)	1.35 c	15.37 a-d	2.43 def	0 c
Furore 0.5	1.28 c	2.10 ef	7.87 a	2.10 bc
Furore 1.5	0.94 c	0 f	6.90 ab	5.70 b
Furore 0.5 + Metribuzin 0.75	1.62 bc	14.87 a-d	3.10 b-f	0 c
Furore 1.5 + Metribuzin 0.75	2.35 bc	4.93 def	5.37 a-d	0.96 bc
Illoxan 0.72	0.82 c	10.33 c-f	2.80 c-f	3.87 bc
Illoxan 1.08	1.01 c	2.23 ef	7.47 a	3.37 bc
Illoxan 0.72 + Metribuzin 0.75	3.56 b	9.53 c-f	4.10 a-e	0.03 c
Illoxan 1.08 + Metribuzin 0.75	1.92 bc	5.53 def	6.37 abc	2.23 bc
Onecide 0.175	0.78 c	12.60 b-e	3.33 b-f	1.73 bc
Onecide 0.525	0.63 c	2.27 ef	3.47 b-f	16.93 a
Onecide 0.175 + Metribuzin 0.75	1.49 bc	5.13 def	5.10 a-d	2.00 bc
Onecide 0.525 + Metribuzin 0.75	2.18 bc	5.13 def	5.57 a-d	0.30 bc
Nabu 0.2	0.96 c	24.87 a	0 f	1.03 bc
Nabu 0.4	0.93 c	8.07 def	2.40 def	3.93 bc
Nabu 0.2 + Metribuzin 0.75	1.46 bc	10.43 c-f	4.27 a-e	0 c
Nabu 0.4 + Metribuzin 0.75	1.82 bc	20.00 abc	2.17 def	0 c

[z]Transplanted on July 3, and harvested on September 7, 14, 17. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).
[y]Applied preemergence (July 3) and postemergence to weeds (July 13). For treatments 5 to 20, all chemicals were applied postemergence at the four-leaf grass stage, except Metribuzin which was applied preemergence. [x]*Eleusine indica, Digitaria spp., Echinochloa colonum.* [w]*Cyperus rotundus.* [v]*Amaranthus spp., Portulaca oleracea.*

Materials and Methods

A split-plot design with four replications was used. Main plots consisted of three spacings between rows – 1.0, 1.2, and 1.5 m-and the subplots had three spacings between plants – 0.3, 0.4, and 0.5 m (Table 11). Seedlings were transplanted on March 1 after 37 days.

Results

Yield was significantly affected by the spacing between rows (Table 12). The yield decreased as the spacing between plants increased from 0.3 to 0.5 m (from 29.6 t/ha to 26.6 t/ha). Yield difference was attributed to fruit number per unit area. This means that the plant population was too low. Fruit size was not affected by spacing between rows.

Conclusion

The combined spacings of 1.5 m between rows and 0.4 and 0.5 m between plants showed the lowest yield. The population density of Tainan No. 2 should be more than 16,600 plants/ha, thus, the 1.2 × 0.4 m space is recommended.

Table 11. Treatments.

Treatment	Spacing between Row (m)	Spacing between Plants (m)	Population per hectare
1	1.0	0.3	33,333
2	1.0	0.4	25,000
3	1.0	0.5	20,000
4	1.2	0.3	27,777
5	1.2	0.4	20,833
6	1.2	0.5	16,666
7	1.5	0.3	22,222
8	1.5	0.4	16,666
9	1.5	0.5	13,333

Table 12. Effect of spacing on mature fruit yield of spring tomato, 1984.[z]

Spacing between Rows (m)	Spacing between Plants (m)[y]			Mean
	0.3	0.4	0.5	
	t/ha			
1.0	29.1	31.6	28.7	29.8
1.2	29.7	31.5	28.6	29.9
1.5	29.9	24.0*	22.5*	25.5
Mean	29.6	29.0	26.6	

[z]Seeds sown on January 24, transplanted on March 1, and harvested on May 7, 16, and 24. [y]Numbers in the same column followed by an asterisk are significantly different from the 1.5 × 0.3 m spacing combination by the 5% LSD test. Main factor (spacing between rows) = NS. Sub-factor (spacing between plants) = 2.81.

Effect of Population Density and Row Spacing on Soybean Yield

Introduction

Recent research on row width and plant density has generally shown that soybean has a remarkable ability to compensate for wide differences in seeding rate, and that yield increases can be achieved by narrowing row width. These studies have been conducted mostly in the

USA with cultivars developed there. The objective of this study was to clarify the effects of row spacing and plant population density on the performance of AVRDC soybean selection AGS19.

Materials and Methods

A field experiment employing the split-plot design with four replications was conducted in spring 1984. The main plot consisted of two interrow spacings (25 and 50 cm), and subplots of five population densities (200,000, 400,000, 600,000, 800,000, 1,000,000 plants/ha). Individual plots were 2 × 6 m in size. To obtain the desired population densities, an excess of AGS19 seeds were sown, and thinned 23 days after planting (DAP). Applied as basal fertilizers were N (20 kg/ha), P_2O_5 (100 kg/ha), and K_2O (100 kg/ha). At flowering, an additional 20 kg N/ha was side-dressed. Soybeans were harvested 126 DAP on June 11, 1984.

Results

The results are presented in Table 13. These data show that plant height and seed weight significantly increased with the increase in population density. A higher population resulted in less branches and pods per plant. Seed number per pod was not affected greatly by plant population, although the highest population gave the lowest seed number. Although the lowest yield was obtained from the highest population of 1,000,000 plants/ha, soybean yield was not affected significantly by population density. Row spacing also did not have any significant effect on yield and the yield components of soybean, but plant height was increased with a wider row width. There was a significant negative correlation between plant height and pod number. A high population seemed to cause lodging.

Table 13. Plant height, yield components, and yield of soybean as affected by plant population and row spacing, spring 1984.[z]

Treatment	Plant Height at 50 DAP (cm)	Branch (no./plant)	Pod (no./plant)	Seed (no./plant)	100-Seed Wt Wt (g)	Yield (t/ha)
Population (plants/ha)						
200,000	19.8 c	2.6 a	41.0 a	2.24 a	19.3 c	3.51 a
400,000	23.8 b	1.5 b	23.6 b	2.26 a	20.3 bc	3.63 a
600,000	25.1 b	0.7 c	17.6 c	2.16 ab	20.6 abc	3.71 a
800,000	28.2 a	0.5 c	15.3 cd	2.21 a	21.8 ab	3.67 a
1,000,000	28.2 a	0.4 c	13.1 d	2.07 b	22.1 a	3.40 a
Row Spacing (cm)						
25	23.8 b	1.2 a	22.5 a	2.14 a	21.1 a	3.72 a
50	26.2 a	1.1 a	21.7 a	2.23 a	20.6 a	3.46 a

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).

Conclusion

The results indicated that soybean plants compensated for low plant density by increasing branches and pod number per plant. Thus, the yield remained relatively constant over a wide range of plant populations. Row spacing also had no significant effect on grain yield. The plant density of 400,000 plants/ha is recommended to avoid a great decrease in plant population during an unfavorable climate in the growing season. A plant spacing of 25 cm between rows would be profitable for AGS19.

Herbicide Evaluation for Soybean

Introduction

Recently, many preemergence herbicides have been screened and their usefulness for soybean weed control confirmed. However, there is a dearth of information on these herbicides at AVRDC. This year four postemergence herbicides, (Furore, Illoxan, Onecide, and Nabu) were tested in summer. Metolachlor and Oxyfluorfen (preemergence herbicides) were also included for comparison.

Materials and Methods

A field trial was conducted in summer 1984. Individual plots were 2 × 6 m in size. The soybean cultivar AGS19 was planted at a spacing of 10 and 25 cm between hills and between rows, respectively. Herbicides tested were Metolachlor, Furore, Illoxan, Onecide, and Nabu (alone or in combination with Oxyfluorfen). Metolachlor and Oxyfluorfen were applied to the soil surface immediately after planting; whereas Furore, Illoxan, Onecide, and Nabu were used postemergence at the four-leaf grass stage. Treatments were replicated three times in a randomized complete block design. Prior to sowing, fertilizers were applied at the rate of 20, 80, and 100 kg/ha of N, P_2O_5, and K_2O, respectively. Additional N (20 kg/ha) was side-dressed at flowering.

Results

Grasses were the major weeds during the summer trial (Table 14). A yield loss of 61% resulted when weeds were left unchecked for the entire growing season. Since infestation of broadleaf weeds was low, the effectiveness of Oxyfluorfen in controlling them was not confirmed. The dominant grassy weeds were jungle rice and goose grass, and they were

Table 14. Influence of herbicide treatments on weed density, summer 1984.[z]

Herbicide	Rate (kg a.i./ha)	Weed Count 50 DAP (no./m²)[y]			
		G	BL	PN	R
Weedy check	–	168 a	12 a-e	26 bc	27 a
Weed-free check	–	0 e	0 e	0 c	0 a
Metolachlor	2.0	4 e	0 e	18 bc	17 a
Metolachlor + Oxyfluorfen	2.0 + 0.115	1 e	3 de	13 bc	18 a
Furore	0.5	1 e	17 a-e	48 abc	41 a
	1.5	0 e	27 a	81 a	21 a
Furore + Oxyfluorfen	0.5 + 0.115	0 e	17 a-e	27 bc	42 a
	1.5 + 0.115	0 e	8 b-e	28 bc	43 a
Illoxan	0.72	53 cd	8 b-e	23 bc	49 a
	1.08	19 de	11 a-e	47 abc	34 a
Illoxan + Oxyfluorfen	0.72 + 0.115	5 e	5 cde	80 a	46 a
	1.08 + 0.115	6 e	8 b-e	40 abc	32 a
Onecide	0.175	87 bc	14 a-e	19 bc	37 a
	0.45	17 de	18 a-d	39 abc	38 a
Onecide + Oxyfluorfen	0.175 + 0.115	16 de	3 de	28 bc	62 a
	0.45 + 0.115	3 e	8 b-e	58 ab	20 a
Nabu	0.2	109 b	17 a-e	25 bc	28 a
	0.4	22 de	23 abc	49 abc	24 a
Nabu + Oxyfluorfen	0.2 + 0.115	33 de	3 de	29 bc	26 a
	0.4 + 0.115	8 e	24 ab	64 ab	24 a

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test(DMRT) [y]G = grass, BL = broadleaf, PN = purple nutsedge, R = rice.

controlled satisfactorily by all the herbicide treatments, except Illoxan at 0.72 kg/ha, Onecide at 0.175 kg/ha, and Nabu at 0.2 kg/ha.

Volunteer rice and purple nutsedge grew in the field, but were not affected by herbicide treatments. The soybean crop was damaged by a high Furore rate in the early growth stage, but it recovered rapidly as the growth stage advanced; hence, no yield reduction was observed (Table 15). Both Oxyfluorfen and Illoxan also caused slight phytotoxicity. All herbi-cide-treated plants (except with Illoxan at 0.72 kg/ha and Onecide at 0.175 kg/ha) yielded as high as the weed-free check. Better weed control gave higher numbers of pods per plant.

Conclusion

Furore was phytotoxic at 1.5 kg/ha. Postemergence application of Furore, Nabu, a high rate of Illoxan and Onecide, or preemergence application of Metolachlor provided adequate weed control in summer when the infestation of broadleaf weeds was relatively low. The combination of Oxyfluorfen and a low rate of Illoxan or Onecide was also effective.

Table 15. Effect of herbicides on grass density, yield, and pod number of soybean, summer 1984.[z]

Herbicide	Rate (kg a.i./ha)	Yield (t/ha)	Grass (no./m^2)	Pod (no./plant)
Weedy check	–	1.47 d	168 a	12.6 d
Weed-free check	–	3.77 a	0 e	26.7 ab
Metolachlor	2.0	3.83 a	4 e	28.1 a
Metolachlor + Oxyfluorfen	2.0 + 0.115	3.73 ab	1 e	28.5 a
Furore	0.5	3.85 a	1 e	26.9 ab
	1.5	3.61 ab	0 e	23.7 abc
Furore + Oxyfluorfen	0.5 + 0.115	3.78 a	0 e	26.5 ab
	1.5 + 0.115	3.65 ab	0 e	25.9 abc
Illoxan	0.72	2.98 bc	53 cd	20.5 c
	1.08	3.79 a	19 de	26.5 ab
Illoxan + Oxyfluorfen	0.72 + 0.115	3.83 a	5 e	26.8 ab
	1.08 + 0.115	3.92 a	6 e	29.0 a
Onecide	0.175	2.80 c	87 bc	21.6 bc
	0.45	3.69 ab	17 de	27.0 ab
Onecide + Oxyfluorfen	0.175 + 0.115	3.75 ab	16 de	24.2 abc
	0.45 + 0.115	3.84 a	3 e	28.5 a
Nabu	0.2	3.32 abc	109 b	23.8 abc
	0.4	3.50 abc	22 de	23.4 abc
Nabu + Oxyfluorfen	0.2 + 0.115	3.34 abc	33 de	26.8 ab
	0.4 + 0.115	3.79 a	8 e	26.6 ab

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test(DMRT).

Herbicide Evaluation for Mungbean

Introduction

Weed infestation often causes severe yield reduction in mungbean. Manual weeding operations are time-consuming and labor-intensive. Hence, the use of herbicides may be profitable. Previous herbicide trials were mostly on preemergence herbicides. This study was aimed at evaluating the effect of postemergence herbicides (Furore, Illoxan, Onecide, and Nabu) on mungbean grown during the summer season. Metolachlor and Oxyfluorfen (preemergence) were included for comparison.

Materials and Methods

A field study was carried out in summer 1984. The experimental design was a randomized complete block with three replications. Plot size was 2 × 6 m with eight rows of mungbean spaced 25 cm apart between rows and 10 cm within rows. The herbicides tested were Metolachlor, Furore, Illoxan, Onecide, and Nabu (alone or in combination with Oxyfluorfen). Both Metolachlor and Oxyfluorfen were applied preemergence; while Furore, Illoxan, Onecide, and Nabu were applied postemergence at the four-leaf grass stage. The mungbean breeding line VC1973A was used as the test crop.

Results

Jungle rice, goose grass and purple nutsedge were the major weeds during the summer season (Table 16). Yield loss due to weed infestation was about 55%. Purple nutsedge could not be controlled by any herbicide treatment. Grasses were effectively controlled by all herbicide treatments, except Onecide at 0.175 kg/ha and Nabu at 0.2 kg/ha, with or without Oxyfluorfen. Crop injuries were found on young mungbean plants in the plots treated with Oxyfluorfen and Furore; the damage was much more severe with Furore. However, both of them gave no yield reduction as compared with that of the weed-free check. All treatments, except a single application of Illoxan at 0.72 kg/ha, Onecide at 0.175 kg/ha, and Nabu at 0.2 kg/ha, yielded higher than the weedy check and as high as the weed-free check.

Plant stand was slightly lower than the weed free check only in the Onecide (0.175 kg/ha) and Nabu (0.2 kg/ha) plots (Table 17). Also, there were no significant differences between any of the treatments with regard to pod number per plant.

Table 16. Effect of herbicides on mungbean seed yield and weed density, summer 1984.[z]

Herbicide	Rate (kg a.i./ha)	Yield (t/ha)	Weed Count 50 DAP (no./m²)[y]			
			G	BL	Pn	R
Weedy check	–	0.93 d	137 a	17 bc	38 cde	0 c
Weed-free check	–	2.09 a	0 d	0 d	0 e	0 c
Metolachlor	2.0	1.99 ab	0 d	4 cd	28 de	5 c
Metolachlor + Oxyfluorfen	2.0 + 0.115	1.90 ab	1 d	12 bcd	28 de	3 c
Furore	0.5	1.77 ab	2 d	33 a	70 a-d	7 bc
	1.5	1.92 ab	0 d	21 ab	97 abc	8 bc
Furore + Oxyfluorfen	0.5 + 0.115	2.00 ab	0 d	14 bcd	83 a-d	5 c
	1.5 + 0.115	1.91 ab	2 d	12 bcd	98 ab	7 bc
Illoxan	0.72	1.52 bc	28 cd	19 abc	67 a-d	13 abc
	1.08	1.71 ab	28 cd	18 bc	58 a-e	10 bc
Illoxan + Oxyfluorfen	0.72 + 0.115	1.98 ab	2 d	4 cd	64 a-d	26 a
	1.08 + 0.115	1.97 ab	3 d	10 bcd	51 a-e	8 bc
Onecide	0.175	1.04 d	133 a	22 ab	45 a-e	8 bc
	0.45	1.90 ab	23 cd	14 bcd	103 a	8 bc
Onecide + Oxyfluorfen	0.175 + 0.115	1.64 abc	32 cd	12 bcd	38 cde	11 bc
	0.45 + 0.115	1.75 ab	3 d	12 bcd	53 a-e	2 c
Nabu	0.2	1.17 cd	91 b	21 ab	39 b-e	2 c
	0.4	1.92 ab	9 cd	23 ab	65 a-d	14 abc
Nabu + Oxyfluorfen	0.2 + 0.115	1.77 ab	50 c	13 bcd	66 a-d	12 bc
	0.4 + 0.115	2.04 ab	7 cd	15 bcd	56 a-e	20 ab

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test(DMRT). [y]G = grass; BL = broadleaf; PN = purple nutsedge; R = rice.

Table 17. Effect of herbicides on plant stand and pod number of mungbean, summer 1984.[z]

Herbicide	Rate (kg a.i./ha)	Plant Stand (no./m^2)	Pod (no./plant)
Weedy check	–	30.6 de	6.4 a
Weed-free check	–	36.1 abc	13.2 a
Metolachlor	2.0	36.4 abc	11.0 a
Metolachlor + Oxyfluorfen	2.0 +0.115	32.3 cde	9.8 a
Furore	0.5	35.7 abc	7.8 a
Furore + Oxyfluorfen	0.5 +0.115	34.9 aoc	10.2 a
	1.5 +0.115	34.6 a-d	11.1 a
Illoxan	0.72	36.3 abc	9.5 a
	1.08	34.5 a-d	8.2 a
Illoxan + Oxyfluorfen	0.72 +0.115	36.9 ab	11.9 a
	1.08 +0.115	34.5 a-d	13.3 a
Onecide	0.175	29.8 e	6.6 a
	0.45	36.0 abc	9.8 a
Onecide + Oxyfluorfen	0.175 + 0.115	32.9 b-e	12.0 a
	0.45 +0.115	32.4 cde	10.7 a
Nabu	0.2	30.1 e	8.5 a
	0.4	35.3 abc	12.3 a
Nabu + Oxyfluorfen	0.2 +0.115	34.7 abc	10.8 a
	0.4 +0.115	37.2 a	11.3 a

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).

Conclusion

A single application of Oxyfluorfen and Furore caused crop injuries, but did not affect mungbean yield. A postemergence application of Furore, or a high rate of Illoxan, Onecide, or Nabu, as well as a preemergence application of Metolachlor, was effective in controlling heavy grass infestations in mungbean during the summer season.

Garden Program

The AVRDC garden program aims to increase nutritional status and income of the people through research, development, training, and extension of school, home, and market garden technologies. In the first year efforts were concentrated on finding out which crops would give maximum yield and a significant output of selected nutrients. The second year "fine-tuned" some of the garden technologies.

The third year continued garden technology development, incorporated it into the AVRDC training program, and transferred the technolog, to Thailand. In Thailand in-country garden research was conducted at AVRDC's Thailand Outreach Program (AVRDC/TOP), and a village-level socioeconomic study of gardens was initiated among a group of small-farm families. Each year few more promising crops, now totalling 57 (Table 1, see next page), were added to the garden activities, their selection reflecting the seasonal pattern of the AVRDC environment (Fig. 1).

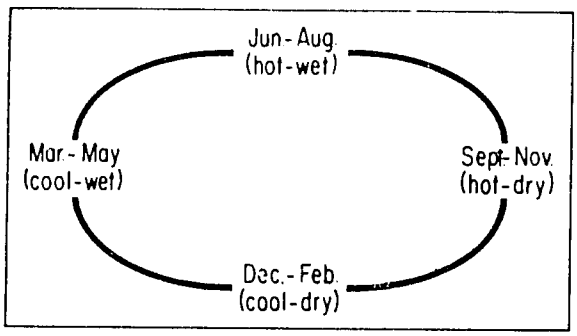


Fig. 1.
Seasonal pattern of AVRDC gardens, Taiwan.

School Garden

Introduction

Schoolchildren need energy and body-building protein food to meet the demands of their growing bodies. In addition, they require vitamins and minerals, which vegetables can provide. A small amount of cooked vegetables added to rice-box lunches that many children bring to school in Southeast Asia could significantly contribute to a child's daily needs for certain vitamins and minerals. The objective of this project is to develop a garden that can be grown in school to provide 1/2 cup (approximately 113 g edible portion) of nutritious vegetables to a minimum of 100 children, five days per week throughout the school year.

Materials and Methods

Four "seasonal" gardens were planted, from December 1983 through November 1984, in a 10 × 18 m plot consisting of twelve raised beds (10 m × 1.5 m × 24 cm). A commercial basal fertilizer was applied when the beds were constructed, and compost was applied thereafter

Table 1. The 57 crops grown in the AVRDC gardens, 1983-84.

Common Name	Scientific Name	Common Name	Scientific Name
1. Amaranth	*Amaranthus mangostanus* L.	30. Lemon grass (citronella grass,geronium grass)	*Cymbopogon citratus*
2. Basil	*Ocimum basilicum*	31. Lettuce	*Lactuca sativa*
3. Bitter gourd (Balsam pear)	*Momordica charantia*	32. Malunggay	*Moringa oleifera*
4. Bottle gourd	*Lagenaria siceraria*	33. Mango	*Mangifera indica*
5. Broccoli	*Brassica oleracea* var. italica	34. Mungbean	*Vigna radiata*
6. Cabbage	*Brassica oleracea* var. capitata	35. Mustard	*Brassica juncea*
7. Carrot	*Caucus carota* var. sativa	36. Okra	*Hibiscus esculentus*
8. Cassava	*Manihot esculenta*	37. Pai-tsai	*Brassica campestris* Chin.
9. Cauliflower	*Brassica oleracea* var. botrytis	38. Papaya	*Carica papaya*
10. Celery	*Apium graveolens*	39. Peanut	*Arachis hypogaea*
11. Cherry radish	*Raphanus sativus*	40. Pumpkin	*Cucurbita moschata*
12. Chinese cabbage	*Brassica campestris* ssp. pekinensis	41. Radish	*Raphanus sativus*
13. Chinese leek	*Allium odorum*	42. Rape green	*Brassica napus*
14. Ching-chiang pai-tsai (spoon cabbage)	*Brassica campestris* var. chinensis	43. Shallot	*Allium ascalonicum*
15. Coriander	*Coriandrum sativum*	44. Snake gourd	*Trichosanthes cucumerina*
16. Corn	*Zea mays*	45. Snap bean	*Phaseolus vulgaris*
17. Cowpea	*Vigna unguiculata* subsp. unguiculata	46. Snow pea	*Pisum sativum*
18. Cucumber	*Cucumis sativus*	47. Spinach	*Spinacia oleracea*
19. Eggplant	*Solanum melongena*	48. Sponge gourd	*Luffa cylindrica*
20. Garland chrysanthemum	*Chrysanthemum coronarium*	49. Sweet corn	*Zea mays* L.
21. Garlic	*Allium sativum*	50. Sweet pepper	*Capsicum annuum*
22. Ginger	*Zingiber officinale*	51. Sweet potato tips (leaves)	*Ipomoea batatas*
23. Hot pepper (bird chillies, cherry capsicum)	*Capsicum frutescens*	52. Taro	*Colocasia esculenta*
24. Hyacinth bean	*Dolichos lablab*	53. Tomato	*Lycopersicon esculentum*
25. Ipil-ipil	*Leucaena leucocephala*	54. Vegetable soybean	*Glycine max.*
26. Kale	*Brassica oleracea* var. acephala	55. Welsh onion	*Allium fistulosum*
27. Kang kong (water convolvulus)	*Ipomoea aquatica*	56. Winged bean	*Psophocarpus tetragonolobus*
28. Kohlrabi	*Brassica oleracea* var. gongylodes	57. Yard-long bean (asparagus bean, pea bean)	*Vigna unguiculata* var. sesquipedalis
29. Leaf beet	*Beta vulgaris*		

throughout the year. The choice of vegetables grown was based on seasonal adaptability, cultural acceptability, and nutritional value. Low-input agricultural procedures were practiced with minimum use of pesticides. Where possible, hand weeding and hand pest control were practiced. Screening was also used over the beds to control airborne insects during the early stages of crop growth.

Edible yield was recorded for each vegetable in each planting period. The vegetables were also analyzed for their content of protein, calcium, iron, and vitamins A and C. The contribution that 1/2 cup of vegetables would make to the daily recommended dietary allowance (RDA) of an average 10-year-old school child was also calculated.

Results

The yield and nutritional composition of vegetables in the school garden are shown in Tables 2 to 5. During the complete year the school garden produced an average of 16.09 kg of nutritious, culturally acceptable vegetables per day. Significant amounts of protein, iron, calcium, and Vitamins A and C were contained in the 16.09 kg (Table 6). The 1/2 cup portion can contribute significantly to the daily diet of a ten-year-old schoolchild, especially in iron and Vitamins A and C (Table 7).

Conclusion

A 10 × 18 m school garden can provide 142 children with 1/2 cup of vegetables per day. Garden size can be expanded or contracted to better reflect a school population size. During long school vacations the gardens can be turned into food for the community, or their harvests can be sold and turned into income for the school.

Home Garden

Introduction

Vegetables, especially the green leafy types, contain nutrients (e. g., protein, calcium, iron, and Vitamins A and C) that are lacking in the diets of many people in Southeast Asia and other parts of the world. Home gardens were developed at AVRDC for Indonesia, the Philippines, and Thailand, for urban homes, and for Vitamin A content.

The objective of this project was to develop small home gardens that contain an intercrop of nutritious vegetables (and a few fruits) which are culturally acceptable in Southeast Asia, and can provide a family of five (two adults and three children) with reasonable percentages of their RDA of calcium, iron, Vitamins A and C, plus measurable amounts of protein. The protein yield from the gardens was not expected to be high, but the protein quality from dark, green, leafy vegetables is good and can enhance uptake of other nutrients.

Materials and Methods

In the Indonesia, Thailand, Philippines, and Vitamin A gardens, a culturally acceptable intercrop of vegetables and a few fruits was planted in 4 × 4.5 m plots consisting of three raised beds (4 m × 1.5 m × 25 cm) per plot. Herbs and spices (e.g., coriander, lemon grass, garlic, shallot,hot pepper, ginger) were planted around the edges of garden beds. As with the school garden,each type of home garden was planted four times during the year in response to the slight seasonal changes in the AVRDC environment.

A smaller selection of crops was planted in the urban home garden. The crops were planted in eight wooden boxes, 115 × 35 × 15 cm. The area of each box was 0.4 m^2 or a total of 3.2 m^2. Boxes were stacked in step-wise fashion on a metal frame to receive equal and

maximum sunlight. Crops were replanted after each harvest, with each box planted five to eight times during the year. Compost was used as the main source of fertilizer.

Low-input agricultural procedures were practiced in all gardens, such as hand weeding, manual insect removal, rice-straw mulch, and plastic screening of beds or boxes during the early growth stages to protect the crops from insect damage. During the seasonal growing periods, data were collected on the yield of each crop in each garden. Samples of each crop were analyzed for protein, calcium, iron, and Vitamins A and C. The RDA for a family of five was obtained from literature (Table 8), and from these data the RDA percentage available to a family of five was determined from each crop and for each garden.

Results

The yield and nutritional composition of the crops grown in representative seasonal gardens are shown for the Indonesia (Tables 9 to 12), Thailand (Tables 13 to 16), Philippines (Tables 17 to 20), and Vitamin A gardens (Tables 21 to 24). Mean contribution of the four seasons of each type of garden is summarized in Table 25. The output of all of the gardens in all seasons was good this year. Daily harvests were kept between 0.85 and 1.0 kg per day, resulting in more uniform nutritional outputs during the year. Normally low yields during the hot and wet seasons were raised by increasing the variety of crops grown during the period.

The yield of the crops grown during the year in the urban home garden are summarized in Table 26. The garden produced an average of 0.24 kg of nutritious vegetables per day, with something to harvest 326 times during the year. Nutritional composition of the crops and their contribution to the RDA of a family of five are summarized in Table 26. The contribution is not particularly high in any nutrient, except in Vitamin C.

Conclusion

The yields and nutritional outputs reflect the value of a small 4 × 4 m garden to a family of five in a developing country. These gardens have consistently produced an impressive amount of selected nutrients necessary for human beings. If these nutrients are normally lacking in the diets of some people, then gardens of this type can help alleviate certain nutritional problems that often result in poor health and low individual productivity.

The yield and nutritional output of the urban home garden was comparatively low. However, there can be 326 harvests during a year from the 3.2 m^2 area; thus, the crop choice was good. In the future, the area will be larger by increasing the number or the size of the boxes in which the crops are grown.

Market Garden

Introduction

The objective of the market garden is to increase the income of small-farm families in developing countries (households earning between US$500 and $1000 per year) by approximately 30%, by developing small income-generating market gardens. These gardens are designed to grow vegetable crops that are in demand at urban markets and which can be grown and sold by urban periphery families who have no other opportunity for employment.

Materials and Methods

Surveys were first conducted at local urban markets to find out which vegetables in the coming months would be low in supply and high in demand, and could therefore command a good price. The most promising of these vegetables were grown in a 10 × 20 m plot consisting of 13 raised beds (10 m × 1.5 m × 25 m). Standard commercial cultural practices were followed;

commercial fertilizers and pesticides were used as needed. Seeds were purchased locally or from commercial companies. At harvest time the vegetables were sold wholesale at local markets. The yield of each vegetable in each seasonal garden, the corresponding wholesale market price, and the gross monetary returns per kilogram were recorded for the year (Tables 27 to 30).

Results

A summary of all four seasonal gardens shows that the garden produced 2,012 kg of market-quality vegetables (Table 31). These sold at the wholesale market for NT$16,818 (US$425). Deducting cash costs (seeds, fertilizer, and pesticide) of NT$1,618 (US$41) the market garden made a net profit of NT$15,200 (US$385). Labor costs were not included under the assumption that unemployed household members will do the labor.

Conclusion

The market garden demonstrated that it could increase the annual net income of a small-farm family by more than 30%. This percentage could be increased by selling the produce directly to the consumer instead of to wholesalers, as in the case of the AVRDC demonstration market garden.

This type of garden is of value in developing countries where the availability of vegetables at urban markets is low, where there is a peri-urban labor pool without jobs, where there exist certain malnutrition problems, and where governments are attempting to plan and implement income-generating projects in rural and peri-urban areas.

Other Activities

Training at AVRDC

This year the garden program was more solidly phased into the training activities at AVRDC in the five-month vegetable crop production course, in a special two-week course in gardening, and in short-term special purpose training. The linkage between food, nutrition, and agriculture is being taught to training scholars in the AVRDC five-month course and in AVRDC's Thailand Training program. It is planned to expand this to Indonesia and Bangladesh in the coming year.

New Garden

A Mandate Crops Garden was added to take advantage of some of the least utilized planting materials of the AVRDC mandate crops. The target population for AVRDC's crops is mainly the commercial farmer who might require the most utilized varieties of the mandate crops, such as uniform-maturing tomatoes, large-headed hybrid Chinese cabbage, sweet potato for animal feed, mungbean for starch production, and soybean for oil. However, for gardens and home consumption, there are different requirements, such as indeterminate tomato varieties, small-headed open-pollinated Chinese cabbage, vegetable soybean, sweet potato for nutritious leaf production, and mungbean for sprouts in the hot, wet season. The Mandate Crops Garden will be used for demonstration and for screening purposes.

AVRDC initiated a composting garden in the gardening research plots. This garden has a number of attractions, one of which is its potential as a dryland garden. The unique design of the composting garden allows for a minimum use of water, perhaps as little as 20% of what is normally required. If this proves to be the case, the composting garden will take the place of present dryland garden activities and be further researched.

Table 2. Yield and nutrient contribution of school garden I, December 1983 to February 1984, AVRDC.

Crop	Times Harvested	Edible Yield (kg)	Edible Yield/Day (kg)	Nutrient Yield/Day				
				protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Garland chrysanthemum	22	125.90	1.94	29.10	52.40	1474.40	8497.20	327.90
Spinach	9	101.70	1.57	40.80	47.10	1428.70	8525.10	648.40
Garlic	2	.29	.004	.10	.10	4.50	4.60	1.30
Cauliflower	3	26.88	.41	10.70	4.50	155.80	25.00	207.90
Pai-tsai	15	125.40	1.93	34.70	92.60	2856.40	3435.40	1428.20
Ching chiang	6	148.20	2.28	57.00	77.50	4742.40	9074.40	1954.00
Rape green	11	100.40	1.55	32.60	89.90	2232.00	6401.50	742.50
Mustard	6	189.90	2.92	70.10	58.40	5197.60	9198.00	3328.80
Kale	8	51.40	.79	19.00	26.10	1840.70	1975.00	908.50
Radish	2	41.80	.64	6.40	2.60	172.80	–	268.80
Coriander	5	4.44	.07	1.30	1.20	95.10	124.80	37.40
Shallot	25	144.13	2.22	46.60	44.40	2308.80	2841.60	290.80
Eggplant	13	33.33	.51	7.14	3.57	30.30	42.30	60.18
Mustard	10	199.30	3.07	73.70	61.40	5464.60	9670.50	3499.80
Sweet pepper	5	7.10	.11	1.43	.99	13.20	320.76	113.30
Lettuce	12	55.00	.85	14.45	57.80	782.00	3799.50	204.00
Welsh onion	9	42.40	.65	9.56	8.26	560.37	2101.45	250.90
Celery	8	68.90	1.06	5.72	12.83	816.62	140.98	179.88
Total	171	1466.47	22.574	460.40	641.65	30176.59	66178.09	14452.56

Table 3. Yield and nutrient contribution of school garden II, March to May 1984, AVRDC.

Crop	Times Harvested	Edible Yield (kg)	Edible Yield/Day (kg)	Nutrient Yield/Day				
				protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Ching chiang	10	110.50	1.67	41.75	56.78	3473.60	6646.60	1431.19
Shallot	14	55.00	.83	17.43	16.60	863.20	1062.40	108.73
Pai-tsai	15	201.40	3.05	54.90	146.40	4514.00	5429.00	2257.00
Celery	5	89.20	1.35	7.29	16.34	1040.04	179.55	229.10
Garland chrysanthemum	5	57.50	.87	13.05	23.49	661.20	3810.60	147.03
Rape green	4	38.00	.58	12.18	33.64	835.20	2395.40	277.82
Lettuce	19	112.70	1.71	29.07	116.28	1573.20	7643.70	410.40
Mustard	7	64.40	.98	23.52	19.60	1744.40	3087.00	1117.20
Kale	2	2.80	.04	.96	1.32	93.20	100.00	46.00
Spinach	4	38.90	.59	15.34	17.70	536.90	3203.70	243.67
Garlic	45	45.90	.70	16.80	14.00	784.00	798.00	227.50
Amaranth	11	68.80	1.04	31.20	48.88	3026.40	2839.20	551.20
Kang kong	17	163.00	2.47	74.10	148.20	2865.20	8076.90	1185.60
Vegetable soybean	4	13.30	.20	29.34	10.24	31.24	76.60	32.64
Broccoli	8	22.70	.34	10.20	2.72	119.00	792.20	168.64
Yard-long bean	1	1.00	.02	.56	.36	10.20	6.66	5.60
Okra	2	.65	.01	.18	.10	9.00	2.33	1.80
Corn	2	19.30	.29	12.18	2.61	14.50	–	23.20
Total	175	1105.05	16.74	390.05	675.26	22194.48	46149.84	8464.32

Table 4. Yield and nutrient contribution of school garden III, June to August 1984, AVRDC.

Crop	Times Harvested	Edible Yield (kg)	Edible Yield/Day (kg)	Nutrient Yield/Day				
				protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Kang kong	28	307.20	4.66	139.80	279.60	5405.60	15238.20	2236.80
Amaranth	22	143.70	2.18	65.40	102.46	6343.80	5951.40	1155.40
Shallot	5	16.30	.25	5.25	5.00	260.00	320.00	32.75
Okra	40	14.65	.22	3.96	2.20	198.00	51 26	39.60
Lettuce	2	8.50	.13	2.21	8.84	119.60	581.10	31.20
Pai-tsai	32	84.66	1.28	23.04	61.44	1894.40	2278.40	947.20
Cucumber	11	40.10	.61	2.44	1.83	85.40	15.25	42.09
Kale	1	.80	.01	.24	.33	23.30	25.00	11.50
Ching chiang	16	58.36	.88	22.00	29.92	1830.40	3502.40	754.16
Rape green	19	65.20	.99	20.79	57.42	1425.60	4088.70	474.21
Mustard	24	72.05	1.09	26.16	21.80	1940.20	3433.50	1242.60
Cauliflower	4	15.30	.23	5.98	2.53	87.40	15.41	116.61
Carrot	4	23.80	.36	3.60	7.56	129.60	5857.20	37.08
Broccoli	2	9.10	.14	4.20	1.12	49.00	326.20	69.44
Chinese cabbage	1	10.20	.16	2.72	4.16	163.20	614.67	84.80
Yard-long bean	4	21.50	.33	9.24	5.94	168.30	109.89	92.40
Total	215	891.42	13.52	337.03	592.15	20123.80	42408.58	7367.84

Table 5. Yield and nutrient contribution of school garden IV, September to November 1984, AVRDC.

Crop	Times Harvested	Edible Yield (kg)	Edible Yield/Day (kg)	Nutrient Yield/Day				
				protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Kang kong	17	148.00	2.28	68.40	136.80	2644.80	7455.60	1094.40
Okra	8	6.13	.09	1.62	.90	81.00	20.97	16.20
Mustard	16	96.60	1.49	35.76	29.80	2652.20	4693.50	1698.60
Yard-long bean	16	9.16	.14	3.92	2.52	71.40	46.62	39.20
Ching chiang	18	82.50	1.27	31.75	43.18	2641.60	5054.60	1088.39
Broccoli	21	28.02	.43	12 90	3.44	150.50	1001.90	213.28
Pai-tsai	31	125.50	1.93	34.74	92 64	2856.40	3435.40	1428.20
Cucumber	6	12.00	.19	.76	.57	26.60	4.75	13.11
Rape green	23	101.80	1.57	32.97	91.06	2260.80	6484.10	752.03
Shallot	2	2.60	.04	.84	.80	41.60	51.20	5.24
Garlic	2	.90	.01	.24	.20	11.20	11.40	3.25
Kale	9	38.10	.59	14.16	19.47	1374.70	1475.00	678.50
Amaranth	12	41.60	.64	19.20	30.08	1862.40	1747.20	339.20
Hyacinth bean	4	1.08	.02	42.10	25.90	464.40	–	75.60
Vegetable soybean	4	12.80	.20	29.34	10.24	31.24	76.60	32.64
Chinese cabbage	6	25.80	.40	6.80	10.40	408.00	1536.68	212.00
Garland chrysanthmum	3	12.30	.19	2.85	5.13	144.40	832.20	32.11
Spinach	1	1.90	.03	.78	.90	27.30	162.90	12.39
Total	199	746.79	11.51	339.13	504.03	17750.54	34090.62	7734.34

Table 6. A summary of selected nutrients contributed by the four AVRDC school gardens, December 1983 through November 1984.

	Edible Yield/Day (kg)	Food Composition in Edible Yield/Day				
		protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Garden I	22.57	460.40	641.65	30176.59	66178.09	14452.56
Garden II	16.74	390.05	675.26	22194.48	46149.84	8464.32
Garden III	13.52	337.03	592.15	20123.80	42408.58	7367.84
Garden IV	11.51	339.13	504.03	17750.54	34090.62	7734.34
Average	16.09	381.65	603.37	18033.85	47206.78	9504.77

Tabl 7. Percentage of a 10-year-old child's RDA contained in 1/2 cup (113 g) of garden vegetables.[z]

	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
RDA for a 10-year-old	38.00	650.00	7.00	575.00	20.00
Contents in 1/2 cup vegetables	3.23	192.17	6.16	333.23	57.00
Contribution in 1/2 cup to the RDA of a 10-year-old (%).	8.50	29.56	88.00	57.95	285.00

[z]RDA = Recommended dietary allowance. Source: Food and Agriculture Organization. 1974. Handbook on human nutritional requirements. During the 1983-84 year the school garden produced 16.09 kg vegetables per day. This means 142 and 1/2 cup servings.

Table 8. Recommended dietary allowance (RDA) for a family of five (two adults and three children, ages 1 to 12).[z]

	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (μg,RE)	Vitamin C (mg)
Father	37	450	7	750	30
Pregnant mother	38	1100	21	750	50
Child (ages 1 to 3)	16	450	7	250	20
Child (ages 4 to 6)	20	450	7	300	20
Child (ages 10 to 12)	38	650	7	575	20
Total	149	3100	49	2625	140

[z]Source. Food and Agriculture Organization. 1974. Handbook on human nutritional requirements. FAO, Rome.

Table 9. Yield and nutrient contribution of Indonesia Home Garden I, December 1983 to February 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Chinese leek	91	1.75	.19	8	.57	.41	16.53	82.27	6.65
2.	Pai-tsai	88	17.18	.189	27	3.40	9.07	279.72	336.42	139.86
	Rape green	38	.72	.008	1	.16	.46	11.52	33.04	3.83
3.	Kale	86	6.18	.068	11	1.63	2.24	158.44	170.00	78.20
	Mustard	43	2.06	.023	3	.55	.46	40.94	72.45	26.22
4.	Mustard	75	12.82	.141	27	3.38	2.82	250.98	444.15	160.74
	Mustard	55	1.07	.012	2	.28	.24	21.36	37.80	13.68
5.	Lettuce	65	3.31	.036	7	.61	2.44	33.12	160.92	8.64
	Amaranth	16	1.68	.018	3	.54	.84	52.38	49.14	9.54
	Radish	51	.94	.010	2	.10	.04	2.70	–	4.20
	Shallot	91	3.08	.034	7	.71	.68	35.36	43.52	4.45
	Garlic	91	1.33	.015	4	.36	.30	16.80	17.10	4.87
6.	Ching chiang	91	20.31	.223	27	5.57	7.58	463.84	887.54	191.11
7.	Garland chrysanthemum	78	8.82	.097	12	1.45	2.61	73.72	424.86	16.39
	Radish	8	2.59	.028	2	.28	.11	7.56	–	11.76
	Mustard	59	2.16	.024	4	.57	.48	42.72	75.60	27.36
8.	Kang kong	7	1.23	.014	2	.42	.84	16.24	45.78	6.72
	Spinach	71	4.28	.047	8	1.22	1.41	42.77	255.21	19.41
9.	Chinese cabbage	15	4.24	.047	6	.79	1.22	47.94	180.55	24.91
	Rape green	52	5.02	.055	7	1.15	3.19	79.20	227.15	26.34
	Celery	76	.39	.004	1	.02	.04	3.08	5.32	.67
Fence										
	Cassava	91	.23	.003	1	.06	.33	4.53	6.36	1.11
	Tomato	91	.46	.005	3	.04	.02	.85	5.55	1.17
	Welsh onion	91	.26	.003	1	.04	.03	2.58	9.69	1.15
	Coriander	91	.16	.002	1	.03	.03	2.71	3.56	1.06
Total			102.27	1.125	177	23.93	37.89	1707.59	3573.98	790.04
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						16.06	77.33	55.08	136.15	564.31

Table 10. Yield and nutritient contribution of Indonesia Home Garden II, March to May 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (µg, RE)	Vitamin C (mg)
1.	Chinese leek	92	4.97	.054	8	1.62	1.19	46.98	233.82	18.90
2.	Rape green	92	3.51	.038	5	.80	2.20	54.72	156.94	18.20
	Spinach	40	1.63	.018	2	.47	.54	16.38	97.74	7.43
	Lettuce	35	1.37	.015	1	.26	1.02	13.80	67.05	3.60
	Amaranth	58	2.14	.023	3	69	1.08	66.93	62.79	12.19
3.	Kang kong	92	6.90	.075	10	2.25	4.50	87.00	245.25	36.00
4.	Mustard	15	.31	.003	1	.07	.06	5.34	9.45	3.42
	Leaf beet	33	3.53	.038	5	.91	.76	67.64	119.70	43.32
	Kale	77	2.18	.024	2	.58	.80	55.92	60.00	27.60
5.	Pai-tsai	56	6.27	.068	7	1.22	3.26	100.64	121.04	50.32
	Lettuce	39	2.71	.029	4	.49	1.97	26.68	129.63	6.96
6.	Ching chiang	36	5.25	.057	8	1.43	1.94	118.56	226.86	48.85
	Yard-long bean	84	2.35	.026	5	.73	.47	13.26	8.66	7.28
	Lettuce	51	2.74	.030	4	.51	2.04	27.60	134.10	7.20
7.	Ching chiang	64	5.23	.057	6	1.43	1.94	118.56	226.86	48.85
	Kang kong	56	1.92	.021	3	.63	1.26	24.36	68.67	10.08
8.	Spinach	14	3.84	.042	6	1.09	1.26	38.22	228.06	17.35
	Celery	64	3.28	.036	3	.19	.44	27.73	4.79	6.11
	Mustard	59	2.98	.032	5	.77	.64	56.96	100.80	36.48
9.	Pai-tsai	19	3.70	.040	2	.72	1.92	59.20	71.20	29.60
	Celery	5	3.13	.034	5	.18	.41	26.19	4.52	5.77
	Cherry radish	74	1.90	.021	7	.21	.08	5.67	–	8.82
Fence										
	Tomato	92	1.22	.013	4	.12	.07	2.21	14.43	3.04
	Cassava	92	5.39	.059	7	1.30	6.49	89.09	125.08	22.00
	Ginger	92	.14	.002	1	.03	.03	.38	.18	.08
Total			78.59	.855	114	18.70	36.37	1150.02	2517.62	479.45
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						12.55	74.22	37.10	95.91	342.46

Table 11. Yield and nutrient contribution of Indonesia Home Garden III, June to August 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Chinese leek	92	3.68	.040	11	1.20	.88	34.80	173.20	14.00
	Chinese leek flower	92	.58	.006	2	.15	.13	1.52	12.20	2.21
2.	Amaranth	20	1.54	.017	3	.51	.80	49.47	46.41	9.01
	Kang kong	67	4.85	.053	6	1.59	3.18	61.48	173.31	25.44
3.	Kang kong	21	1.48	.016	3	.48	.96	18.56	52.32	7.68
	Amaranth	56	1.78	.019	4	.57	.89	55.29	51.87	10.07
4.	Kale	7	.79	.009	1	.22	.30	20.97	22.50	10.35
	Pai-tsai	58	3.26	.035	5	63	1.68	51.80	62.30	25.90
	Rape green	32	.21	.002	1	.04	.12	2.88	8.26	.96
5.	Lettuce	1	.72	.008	1	.14	.54	7.36	35.76	1.92
	Rape green	62	4.27	.046	6	.97	2.67	66.24	189.98	22.03
6.	Yard-long bean	5	.24	.003	1	.08	.05	1.53	1.00	.84
	Welsh onion	87	6.17	.067	11	.98	.85	57.76	216.61	25.86
7.	Kang kong	27	2.36	.026	4	.78	1.56	30.16	85.02	12.48
8.	Rape green	32	1.25	.014	4	.29	.81	20.16	57.82	6.71
	Mustard	17	.54	.006	1	.14	.12	10.68	18.90	6.84
	Pai-tsai	55	1.61	.018	3	.32	.86	26.64	32.04	13.32
9.	Pai-tsai	46	.95	.010	3	.18	.48	14.80	17.80	7.40
	Rape green	71	1.81	.020	4	.42	1.16	28.80	82.60	9.58
Fence										
	Cassava	92	22.53	.245	38	5.39	26.95	369.95	519.40	91.39
	Shallot	92	.81	.009	1	.19	.18	9.36	11.52	1.18
	Bottle gourd	92	1.79	.019	2	.11	.03	7.47	7.09	1.60
	Onion	92	1.30	.014	1	.21	.18	12.07	45.26	5.40
Total			64.52	.702	116	15.59	45.38	959.75	1923.17	312.17
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						10.46	92.61	30.96	73.26	222.98

Table 12. Yield and nutrient contribution of Indonesia Home Garden IV, September to November 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg. RE)	Vitamin C (mg)
1.	Chinese leek	70	2.22	.024	5	.72	.53	20.88	103.92	8.40
	Chinese leck flower	70	.66	.007	4	.18	.15	1.78	14.23	2.58
	Kale	66	1.70	.019	3	.46	.63	44.27	47.50	21.85
2.	Amaranth	45	1.38	.015	3	.45	.71	43.65	40.95	7.95
	Chinese cabbage	49	1.87	.021	3	.36	.55	21.42	80.68	11.13
3.	Pai-tsai	35	1.48	.016	3	.29	.77	23.68	28.48	11.84
	Rape green	50	1.68	.019	3	.40	1.10	27.36	78.47	9.10
4.	Rape green	31	2.62	.029	5	.61	1.68	41.76	119.77	13.89
	Mustard	71	5.49	.060	7	1.44	1.20	106.80	189.00	68.40
5.	Mustard	21	4.02	.044	7	1.05	.88	78.32	138.60	50.16
	Pai-tsai	49	3.58	.039	4	.70	1.87	57.72	69.42	28.86
	Ching chiang	40	3.01	.033	4	.83	1.12	68.64	131.34	28.28
6.	Kang kong	56	5.73	.063	10	1.89	3.78	73.08	206.01	30.24
	Lettuce	59	2.30	.025	5	.43	1.70	23.00	111.75	6.00
7.	Kale	13	1.43	.016	3	.38	.53	37.28	40.00	18.40
	Rape green	38	1.00	.011	2	.23	.64	15.84	45.43	5.27
8.	Mustard	63	6.95	.076	11	1.82	1.52	135.28	239.40	86.64
	Rape green	43	.51	.006	1	.13	.35	8.64	24.78	2.87
9.	Amaranth	40	.82	.009	3	.27	.42	26.19	24.57	4.77
	Pai-tsai	36	.65	.007	1	.13	.34	10.36	12.46	5.18
	Yard-long bean	71	1.84	.020	7	.56	.36	10.20	6.66	5.60
Fence										
	Yard-long bean	85	5.92	.065	16	1.82	1.17	33.15	21.65	18.20
	Cassava	91	.89	.010	2	.22	1.10	15.10	21.20	3.73
	Bottle gourd	91	41.87	.460	28	2.62	.64	180.78	171.58	38.73
	Taro (tuber)	91	.94	.010	2	.22	.12	3.40	–	.80
	Taro (leaf stalk)	91	.25	.003	2	.02	.03	1.47	.50	.39
Total			100.81	1.107	144	18.24	23.89	1110.05	1968.75	489.26
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						12.24	48.76	35.81	75.00	349.47

Table 13. Yield and nutrient contribution of Thailand Home Garden I, December 1983 to February 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	91	.23	.003	1	.05	.14	3.49	4.20	.63
	Garland chrysanthemum	91	3.36	.037	7	.56	1.00	28.12	162.06	6.25
2.	Lettuce	21	2.39	.026	7	.44	1.77	23.92	116.22	6.24
	Pai-tsai	82	9.19	.101	14	1.82	4.85	149.48	179.78	74.74
	Mustard	75	.64	.007	2	.17	.14	12.46	22.05	7.98
3.	Kale	91	5.98	.066	11	1.58	2.18	153.78	165.00	75.90
	Mustard	75	1.48	.016	2	.38	.32	28.48	50.40	18.24
	Shallot	91	2.49	.027	4	.57	.54	28.08	34.56	3.54
4.	Mustard	71	11.74	.129	21	3.10	2.58	229.62	406.35	147.06
	Shallot	91	1.72	.019	3	.40	.38	19.76	24.32	2.49
	Mustard	75	.62	.007	1	.17	.14	12.46	22.05	7.98
5.	Lettuce	70	7.10	.078	15	1.33	5.30	71.76	348.66	18.72
	Shallot	91	5.33	.059	9	1.24	1.18	61.36	75.52	7.73
	Garlic	91	1.47	.016	5	.38	32	17.92	18.24	5.20
6.	Ching chiang	85	24.48	.269	23	6.73	9.15	559.52	1070.62	230.53
7.	Radish	15	5.96	.065	6	.39	.45	11.79	6.83	11.17
	Garland chrysanthemum	76	3.62	.040	8	.60	1.08	30.40	175.20	6.76
	Celery	71	.77	.008	2	.04	.10	6.16	1.06	1.36
8.	Kang kong	12	1.33	.015	4	.45	.90	17.40	49.05	7.20
	Spinach	89	4.16	.046	6	1.20	1.38	41.86	249.78	19.00
	Shallot		1.61	.018	2	.38	.36	18.72	23.04	2.36
9.	Lettuce	16	4.29	.047	8	.80	3.20	43.24	210.09	11.28
	Coriander	9	.17	.002	1	.04	.10	1.57	10.57	1.67
	Rape green	50	4.16	.046	6	1.00	2.67	66.24	189.98	22.03
	Shallot		1.73	.019	2	.40	.38	19.76	24.32	2.49
Fence										
	Tomato	91	7.51	.083	19	.75	.42	14.11	92.13	19.42
	Ipil-ipil	91	1.07	.012	3	.80	.87	6.68	84.96	6.07
	Cucumber	91	.91	.010	2	.04	.03	1.40	.25	.69
	Ginger		.36	.004	1	.06	.05	.76	.37	.16
	Snap bean		.06	.001	1	.03	.01	.30	.30	.28
Total			115.93	1.276	196	25.90	39.11	1680.60	3817.56	625.17
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						17.38	79.82	54.21	145.43	446.55

Table 14. Yield and nutrient contribution of Thailand Home Garden II, March to May 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (µg, RE)	Vitamin C (mg)
1.	Lemon grass	92	6.19	.067	9	1.18	3.09	78.01	93.80	13.99
	Garland chrysanthemum	34	2.18	.024	3	.36	.65	18.24	105.12	4.06
	Kang kong	58	1.36	.015	1	.45	.90	17.40	49.05	7.20
2.	Rape green	30	2.85	.031	3	.65	1.80	44.64	128.03	14.85
	Lettuce	46	3.12	.034	3	.58	2.31	31.28	151.98	8.16
3.	Kale	5	.58	.006	1	.14	.20	13.98	15.00	6.90
	Lettuce	77	5.70	.062	7	1.05	4.22	57.04	277.14	14.88
	Amaranth	55	1.07	.012	2	.36	.56	34.92	32.76	6.36
4.	Mustard	19	3.39	.037	5	.89	.74	65.86	116.55	42.18
	Celery	50	2.53	.028	4	.15	.34	21.57	3.72	4.75
	Kang kong	79	6.26	.068	7	2.04	4.08	78.88	222.36	32.64
5.	Spinach	26	.20	.002	1	.05	.06	1.82	10.86	.83
	Pai-tsai	91	6.53	.071	8	1.28	3.41	105.08	126.38	52.54
6.	Ching chiang	20	3.56	.039	2	.98	1.33	81.12	155.22	33.42
	Mustard	59	4.88	.053	6	1.27	1.06	94.34	166.95	60.42
	Amaranth	43	.71	.008	1	.24	.38	23.28	21.84	4.24
7.	Lettuce	31	2.26	.025	4	.43	1.70	23.00	111.75	6.00
	Celery	16	3.22	.035	6	.19	.42	26.96	4.66	5.94
	Ching chiang	68	4.30	.047	5	1.18	1.60	97.76	187.06	40.28
8.	Spinach	33	3.98	.043	7	1.12	1.29	39.13	233.49	17.76
	Shallot	5	1.17	.013	2	.27	.26	13.52	16.64	1.70
	Amaranth	90	3.54	.038	4	1.14	1.79	110.58	103.74	20.14
9.	Rape green	1	.45	.005	1	.11	.29	7.20	20.65	2.40
	Pai-tsai	19	3.90	.042	2	.76	2.02	62.16	74.76	31.08
	Kale	86	3.39	.037	4	.89	1.22	86.21	92.50	42.55
	Leaf beet	32	1.12	.012	2	.20	.58	5.33	19.60	.33
Fence										
	Tomato	92	9.02	.098	16	.88	.49	16.66	108.78	22.93
	Sweet potato tips	92	1.20	.013	4	.52	1.49	17.90	16.25	6.16
	Ipil-ipil	92	8.42	.092	12	6.16	6.70	51.18	651.36	46.55
	Shallot	92	1.60	.017	2	.36	.34	17.68	21.76	2.23
	Garlic	92	1.32	.014	2	.34	.28	15.68	15.96	4.55
Total			100.00	1.088	136	26.22	45.60	1358.41	3355.72	558.03
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						17.60	93.06	43.82	127.84	398.59

Table 15. Yield and nutrient contribution of Thailand Home Garden III, June to August 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	92	19.31	.210	24	3.69	9.68	244.50	294.00	43.84
	Kang kong	14	.58	.006	1	.18	.36	6.96	19.62	2.88
	Amaranth	58	1.28	.014	3	.42	.65	40.74	38.22	7.42
2.	Rape green	8	.74	.008	3	.16	.46	11.52	33.04	3.83
	Ching chiang	43	.98	.011	3	.27	.37	22.88	43.78	9.42
	Kang kong	38	1.29	.014	3	.42	.84	16.24	45.78	6.72
3.	Sweet pepper	92	1.93	.021	9	.27	.18	2.52	61.23	21.63
	Amaranth	28	.94	.010	2	.30	.47	29.10	27.30	5.30
	Basil	92	3.58	.039	11	1.28	1.87	124.80		
4.	Kang kong	34	4.23	.046	5	1.38	2.76	53.36	150.42	22.08
	Pai-tsai	65	1.21	.013	3	.23	.62	19.24	23.14	9.62
5.	Sweet pepper	83	5.56	.060	28	.78	.54	7.20	174.96	61.80
6.	Amaranth	26	1.74	.019	3	.57	.89	55.29	51.87	10.07
	Yard-long bean	53	3.07	.033	18	.92	.59	16.83	10.98	9.24
	Rape green	39	1.37	.015	2	.31	.87	21.60	61.95	7.18
7.	Kang kong	46	2.79	.030	4	.90	1.80	34.60	98.10	14.40
	Mustard	60	.50	.005	1	.12	.10	8.90	15.75	5.70
8.	Amaranth	19	2.35	.026	3	.78	1.22	75.66	70.98	13.78
9.	Lettuce	60	.34	.004	3	.06	.27	3.68	17.88	.96
Fence										
	Ipil-ipil	92	16.40	.178	33	11.90	12.95	99.02	1260.24	90.08
	Bottle gourd	92	7.88	.086	6	.49	.12	33.79	32.07	7.24
	Yard-long bean	92	10.46	.114	29	3.19	2.05	58.14	37.96	31.92
	Sweet potato tips	92	.63	.007	2	.23	.53	9.03	17.99	3.92
Total			89.16	.969	199	28.85	40.19	995.80	2879.75	399.56
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						19.36	82.02	32.12	109.71	285.40

Table 16. Yield and nutrient contribution of Thailand Home Garden IV, September to November 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (µg, RE)	Vitamin C (mg)
1.	Lemon grass	9	7.29	.080	5	1.41	3.69	93.14	112.00	16.70
	Pai-tsai	48	.46	.005	1	.09	.24	7.40	8.90	3.70
	Rape green	30	1.39	.015	3	.32	.87	21.60	61.95	7.19
2.	Kang kong	32	1.87	.021	4	.63	1.26	24.36	68.67	10.08
	Lettuce	31	1.54	.017	6	.29	1.16	15.64	75.99	4.08
3.	Basil	91	6.38	.070	21	2.31	3.36	224.00	525.00	18.90
	Ginger	91	1.20	.013	3	.21	.17	2.47	1.20	.52
4.	Amaranth	43	2.83	031	6	.93	1.46	90.21	84.63	16.43
	Kale	47	1.35	.015	3	.36	.50	34.95	37.50	17.25
5.	Mustard	56	7.40	.081	9	1.94	1.62	144.18	255.15	92.34
	Pai-tsai	49	2.12	.023	4	.41	1.10	34.04	40.94	17.02
6.	Rape green	8	1.85	.020	3	.42	1.16	28.80	82.60	9.58
	Kale	61	1.66	.018	4	.43	.59	41.94	45.00	20.70
	Eggplant	69	3.07	.034	14	.48	.24	2.04	2.82	4.01
7.	Mustard	41	3.13	.034	5	.82	.68	60.52	107.10	38.76
	Pai-tsai	52	1.96	.022	2	.40	1.06	32.56	39.16	16.28
	Rape green	39	.63	.007	1	.15	.41	10.08	28.91	3.35
8.	Kale	11	.40	.004	3	.10	.13	9.32	10.00	4.60
	Yard-long bean	39	1.21	.013	6	.36	.23	6.63	4.33	3.64
	Lettuce	27	1.32	.015	5	.26	1.02	13.80	67.05	3.60
9.	Ching chiang	48	4.07	.045	5	1.13	1.53	93.60	179.10	38.57
	Kang kong	45	.98	.011	2	.33	.66	12.76	35.97	5.28
Fence										
	Ipil-ipil	91	15.66	.172	29	11.51	12.52	95.68	1217.76	87.05
	Bottle gourd	91	1.28	.014	2	.08	.02	5.50	5.22	1.18
	Sweet potato tips	91	.44	.005	2	.20	.57	6.89	6.25	2.37
	Taro (tuber)	91	1.10	.012	2	.26	.14	4.08	–	.96
	Taro (leaf stalk)	91	.44	.005	1	.03	.05	2.45	1.50	.65
	Wingeu bean	91	.18	.002	2	.08	.03	1.62	1.28	.44
	Cucumber	91	.08	.001	1	.004	.003	.14	.03	.07
Total			73.29	.805	154	25.94	36.47	1120.40	3106.01	445.30
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						17.41	74.43	36.14	118.32	318.07

Table 17. Yield and nutrient contribution of Philippine Home Garden I, December 1983 to February 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	91	1.69	.019	2	33	.88	22.12	26.60	3.97
	Lettuce	43	.41	.005	1	.09	.34	4.60	22.35	1.20
	Garland chrysanthemum	42	1.44	.016	4	.24	.43	12.16	70.08	2.70
2.	Pai-tsai	70	9.64	.108	19	1.91	5.09	156.88	188.68	78.44
	Rape green	40	.85	.009	2	.19	.52	12.96	37.17	4.31
	Mustard	53	.14	.002	1	.05	.04	3.56	6.30	2.28
3.	Kale	79	5.61	.062	16	1.49	2.05	144.46	155.00	71.30
4.	Mustard	91	10.57	.116	23	2.78	2.32	206.48	365.40	132.24
5.	Spinach	71	7.39	.081	12	2.11	2.43	73.71	439.83	33.45
	Coriander	29	.08	.001	1	.02	.05	.79	5.28	.83
6.	Ching chiang	89	14.23	.156	23	3.90	5.30	324.48	620.88	133.69
	Celery	76	1.87	.021	5	.11	.25	16.18	2.79	3.56
7.	Garland chrysanthemum	51	2.20	.024	5	.36	.65	18.24	105.12	4.06
	Radish	12	2.43	.027	5	.16	.19	4.90	2.84	4.64
	Spinach	79	1.15	.013	2	.34	.39	11.83	70.59	5.37
	Eggplant	91	.30	.003	3	.04	.02	.18	.25	.35
	Coriander	72	.31	.003	2	.06	.15	2.36	15.85	2.50
8.	Kang kong	5	1.10	.012	3	.36	.72	13.92	39.24	5.76
	Mustard	84	7.95	.087	14	2.09	1.74	154.86	274.05	99.18
9.	Coriander	62	2.13	.023	14	.48	1.13	18.07	121.51	19.19
	Shallot	90	2.33	.026	6	.55	.52	27.04	33.28	3.41
	Garlic		1.15	.013	3	.31	.26	14.56	14.82	4.23
	Lettuce	91	2.11	.023	7	.39	1.56	21.16	102.81	5.52
Fence										
	Tomato	91	10.70	.118	29	1.06	.59	20.06	130.98	27.61
	Cowpea		.41	.005	4	1.14	.33	5.50	.08	.05
	Mustard	75	1.76	.019	5	.46	.38	33.82	59.85	21.66
	Coriander	35	.20	.002	1	.04	.10	1.57	10.57	1.67
	Sweet potato tips		.16	.002	1	.08	.23	2.75	2.50	.95
	Ginger		.10	.001	1	.02	.01	.19	.09	.04
	Snap bean		.08	.001	1	.03	.01	.30	.30	.28
Total			90.49	.996	215	21.19	28.68	1329.69	2825.09	674.44
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						14.22	58.53	42.89	107.62	481.74

Table 18. Yield and nutrient contribution of Philippine Home Garden II, March to May 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	92	10.34	.112	13	1.97	5.16	130.40	156.80	23.38
	Pai-tsai	19	4.44	.048	2	.86	2.30	71.04	85.44	35.52
	Shallot	29	.60	.007	1	.14	.14	7.28	8.96	.91
	Kang kong	52	1.01	.011	2	.33	.66	12.76	35.97	5.28
2.	Spinach	42	.30	.003	1	.07	.09	2.73	16.29	1.23
	Leaf beet	41	2.00	.022	4	.37	1.06	9.77	35.92	.60
	Rape green	19	1.30	.014	2	.29	.81	20.16	57.82	6.70
	Ching chiang	67	3.68	.040	6	1.00	1.36	83.20	159.20	34.28
3.	Lettuce	43	2.07	.023	5	.39	1.56	21.16	102.81	5.52
	Pai-tsai	58	3.58	.039	4	.70	1.87	57.72	69.42	28.86
	Amaranth	58	.86	.009	1	.27	.42	26.19	24.57	4.77
4.	Mustard	19	1.71	.019	2	.45	.38	33.82	59.85	21.66
	Lettuce	42	6.40	.070	8	1.19	4.76	64.40	312.90	16.80
	Amaranth	53	1.31	.014	2	.42	.65	40.74	38.22	7.42
5.	Pai-tsai	48	3.81	.041	3	.73	1.96	60.68	72.98	30.34
	Celery	47	1.93	.021	2	.11	.25	16.17	2.79	3.56
	Spinach	14	.98	.011	2	.28	.33	10.01	59.73	4.54
6.	Celery	63	4.71	.051	7	.27	.61	39.29	6.78	8.65
	Ching chiang	13	1.24	.013	2	.32	.44	27.04	51.74	11.14
	Rape green	51	2.16	.023	4	.48	1.33	33.12	94.99	11.01
	Okra	38	.15	.002	2	.03	.02	1.80	.46	.36
7.	Ching chiang	37	3.14	.034	3	.85	1.15	70.72	135.32	29.13
	Eggplant	91	5.48	.060	15	.84	.42	3.60	4.98	7.08
	Kang kong	73	1.35	.015	3	.45	.90	17.40	49.05	7.20
8.	Pai-tsai	76	4.41	.048	5	.86	2.30	71.04	85.44	35.52
	Mustard	40	1.18	.013	2	.31	.26	23.14	40.95	14.82
	Kang kong	43	1.45	.016	2	.48	.96	18.56	52.32	7.68
9.	Lettuce	41	5.04	.055	7	.93	3.74	50.60	245.85	13.20
	Amaranth	57	1.88	.020	3	.60	.94	58.20	54.60	10.60
Fence										
	Tomato	92	17.29	.188	28	1.69	.94	31.96	208.68	43.99
	Sweet potato tips	92	1.82	.020	6	.68	1.52	25.60	51.40	11.20
	Shallot	92	11.78	.128	8	2.68	2.56	133.12	163.84	16.76
	Garlic	92	1.80	.020	1	.48	.40	22.40	22.80	6.50
	Yard-long bean		.10	.001	1	.02	.01	.51	.33	.28
Total			111.30	1.211	159	21.54	42.26	1296.53	2569.20	466.49
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						14.46	86.24	41.82	97.87	333.21

Table 19. Yield and nutrient contribution of Philippine Home Garden III, June to August 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	92	19.46	.212	28	3.73	9.77	246.93	296.80	44.27
	Kang kong	11	1.43	.016	2	.48	.96	18.56	52.32	7.68
	Mustard	71	2.84	.031	5	.74	.62	55.18	97.65	35.34
2.	Lettuce	28	1.37	.015	3	.26	1.02	13.80	67.05	3.60
	Kale	63	.46	.005	1	.12	.17	11.65	12.50	5.75
3.	Amaranth	40	5.81	.063	6	1.89	2.96	183.33	171.99	33.39
4.	Amaranth	22	3.45	.038	4	1.14	1.79	110.58	103.74	20.14
	Kang kong	50	4.56	.050	7	1.50	3.00	58.00	163.50	24.00
5.	Pai-tsai	60	2.00	.022	3	.40	1.06	32.56	39.16	16.28
6.	Amaranth	19	2.46	.027	3	.81	1.27	78.57	73.71	14.31
	Okra	65	3.20	.035	29	.63	.35	31.50	8.16	6.30
7.	Eggplant	46	6.29	.068	16	.95	.48	4.08	5.64	8.02
	Kang kong	23	.28	.003	1	.09	.18	3.48	9.81	1.44
	Pai-tsai	47	.12	.001	1	.02	.05	1.48	1.78	.74
	Chinese cabbage	47	.69	.008	3	.14	.21	8.16	30.73	4.24
8.	Kang kong	34	3.67	.040	5	1.20	2.40	46.40	130.80	19.20
	Amaranth	59	3.09	.034	5	1.02	1.60	98.94	92.32	18.02
9.	Amaranth	21	2.02	.022	3	.66	1.03	64.02	60.06	11.66
	Ching chiang	72	.25	.003	1	.08	.10	6.24	11.34	2.57
Fence										
	Sweet potato tips		1.68	.018	5	.72	2.06	24.79	22.50	8.53
	Yard-long bean		6.16	.067	22	1.88	1.21	34.17	22.31	18.76
	Bitter gourd		9.42	.102	18	.82	2.35	26.52	18.67	58.14
	Cucumber		.11	.001	2	.004	.003	.14	.03	.07
Total			80.82	.881	173	19.28	34.64	1158.98	1493.67	362.45
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						12.94	70.69	37.39	56.90	258.89

Table 20. Yield and nutrient contribution of Philippine Home Garden IV, September to November 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Lemon grass	53	7.96	.088	12	1.55	4.06	102.46	123.20	18.37
	Ching chiang	61	3.87	.043	7	1.08	1.46	89.44	171.14	36.85
2.	Amaranth	53	1.66	.018	3	.54	.85	52.38	49.14	9.54
	Kale	11	1.52	.017	2	.41	.56	39.61	42.50	19.55
	Lettuce	52	1.96	.022	4	.37	1.50	20.24	98.34	5.28
3.	Vegetable soybean	17	.79	.009	4	1.32	.46	1.41	3.45	1.47
	Ching chiang	28	3.61	.040	5	1.00	1.36	83.20	159.30	34.28
	Eggplant	67	.83	.009	4	.13	.06	.54	.75	1.06
4.	Okra	80	10.99	.121	34	2.18	1.21	108.90	28.19	21.78
5.	Kale	63	2.71	.030	5	.72	.99	69.90	75.00	34.50
6.	Yard-long bean	39	2.30	.025	9	.70	.45	12.75	8.33	7.00
	Lettuce	28	1.47	.016	4	.27	1.09	14.72	71.52	3.84
7.	Chinese cabbage	4	1.24	.014	2	.24	.36	14.28	53.78	7.42
	Mustard	49	2.56	.028	4	.67	.56	49.84	88.20	31.92
	Pai-tsai	50	1.71	.019	3	.34	.91	28.12	33.82	14.06
8.	Amaranth	2	.59	.007	1	.21	.33	20.37	19.11	3.71
	Ching chiang	54	3.34	.037	6	.93	1.26	76.96	147.26	31.71
	Garland chrysanthemum	43	.46	.005	2	.08	.14	3.80	21.90	.85
9.	Ching chiang	3	.30	.003	1	.08	.10	6.24	11.94	2.57
	Kang kong	42	1.90	.021	4	.63	1.26	24.36	68.67	10.08
	Mustard	52	3.76	.041	9	.98	.82	72.98	129.15	46.74
Fence										
	Bitter gourd	4	.25	.003	1	.02	.07	.78	.55	1.71
	Moringa (leaf)	91	3.84	.042	8	2.14	7.52	97.09	287.70	48.40
	Moringa (pod)	91	2.42	.027	5	.70	.87	.88	–	34.86
	Cucumber	91	.42	.005	2	.02	.02	.70	.13	.35
	Sweet potato tips	91	1.16	.013	3	.52	1.49	17.90	16.25	6.16
	Taro (tuber)	91	.79	.009	2	.20	.11	3.06	–	.72
	Taro (leaf stalk)	91	.33	.004	2	.02	.04	1.96	1.20	.52
	Yard-long bean	91	2.27	.025	9	.70	.45	12.75	8.33	7.00
Total			67.01	.741	157	18.75	30.36	1027.62	1718.75	442.30
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						12.58	61.96	33.15	65.48	315.93

Table 21. Yield and nutrient contribution of Vitamin A Home Garden I, December 1983 to February 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Carrot	91	1.68	.018	4	.18	.38	6.48	292.86	1.85
	Sweet pepper	70	1.34	.015	7	.20	.14	1.80	43.74	15.45
	Ching chiang	91	7.66	.084	16	2.10	2.86	174.72	334.32	72.00
2.	Pai-tsai	77	10.09	.111	20	2.00	5.33	164.28	197.58	82.14
	Rape green	41	.67	.007	1	.15	.41	10.08	28.91	3.35
	Mustard	61	.15	.002	1	.05	.04	3.56	6.30	2.28
3.	Chinese leek	91	1.51	.017	5	.51	.37	14.79	73.61	5.95
4.	Rape green	54	6.89	.076	15	1.60	4.41	109.44	313.88	36.40
	Radish	76	1.46	.016	2	.10	.11	2.90	1.68	2.75
	Mustard	54	.23	.003	1	.07	.06	5.34	9.45	3.42
5.	Mustard	85	15.20	.167	25	4.01	3.34	297.26	526.05	190.38
6.	Kale	87	9.16	.101	18	2.42	3.33	235.33	252.50	116.15
7.	Radish	15	6.65	.073	8	.44	.50	13.24	7.67	12.55
	Garland chrysanthemum	76	5.01	.055	11	.83	1.49	41.80	240.90	9.30
	Lettuce	40	.37	.004	1	.07	.27	3.68	17.88	.96
	Celery	75	2.75	.030	4	.16	.36	23.11	3.99	5.09
8.	Kang kong	4	.99	.011	4	.33	.66	12.76	35.97	5.28
	Spinach	69	7.49	.082	17	2.13	2.46	74.62	445.26	33.87
	Pai-tsai	17	1.04	.011	1	.20	.53	16.28	19.58	8.14
9.	Coriander	29	.25	.003	2	.06	.15	2.36	15.85	2.50
	Mustard	56	1.73	.019	2	.46	.38	33.82	59.85	21.66
Fence										
	Tomato		3.10	.034	13	.31	.17	5.78	37.74	7.96
	Sweet potato tips		.92	.010	2	.40	1.14	13.70	12.50	4.74
	Coriander		.08	.001	1	.02	.05	.79	5.28	.83
	Mustard		4.69	.052	11	1.25	1.04	92.56	163.80	59.28
Total			91.11	1.002	192	20.05	29.98	1360.48	3147.15	704.28
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						13.46	61.18	43.89	119.89	503.06

Table 22. Yield and nutrient contribution of Vitamin A Home Garden II, March to May 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Carrot	6	4.23	.046	6	.46	.97	16.56	748.42	4.74
	Celery	53	6.42	.070	8	.38	.85	53.93	9.31	11.88
	Amaranth	47	.74	.008	1	.24	.38	23.28	21.84	4.24
2.	Rape green	65	5.11	.056	6	1.18	3.25	80.64	231.28	26.82
	Ching chiang	64	2.43	.026	4	.65	.88	54.08	103.48	22.28
3.	Chinese leek	92	5.85	.064	9	1.92	1.41	55.68	277.12	22.40
4.	Ching chiang	19	3.62	.039	5	.98	1.33	81.12	155.22	33.42
	Leaf beet	32	2.05	.022	3	.37	1.06	9.78	35.93	.61
	Pai-tsai	44	.40	.004	1	.07	.19	5.92	7.12	2.96
	Kang kong	73	2.38	.026	5	.78	1.56	30.16	85.02	12.48
5.	Mustard	12	.69	.008	1	.19	.16	14.24	25.20	9.12
	Ching chiang	62	6.33	.069	10	1.73	2.35	143.52	274.62	59.13
6.	Lettuce	40	5.04	.055	6	.94	3.74	50.60	245.85	13.20
7.	Lettuce	32	2.15	.023	5	.39	1.56	21.16	102.81	5.52
	Ching chiang	33	1.02	.011	2	.28	.37	22.88	43.78	9.43
	Pai-tsai	33	.40	.004	1	.07	.19	5.92	7.12	2.96
	Amaranth	78	3.26	.035	5	1.05	1.65	101.85	95.55	18.55
8.	Pai-tsai	54	7.02	.076	5	1.37	3.65	112.48	135.28	56.24
	Kang kong	38	3.66	.040	5	1.20	2.40	46.40	130.80	19.20
9.	Carrot	92	5.44	.059	9	.59	1.24	21.24	959.93	6.08
Fence										
	Tomato	92	5.00	.054	11	.49	.27	9.18	59.94	12.64
	Sweet potato tips	92	6.63	.072	15	2.45	5.47	92.88	185.04	40.32
	Papaya	92	6.49	.071	5	–	–	–	156.20	22.78
	Shallot	49	.25	.003	1	.06	.06	3.12	3.84	.39
Total			86.61	.941	129	17.84	34.99	1056.62	4100.70	41[illegible].39
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						11.97	71.41	34.08	156.22	298.14

Table 23. Yield and nutrient contribution of Vitamin A Home Garden III, June to August 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg, RE)	Vitamin C (mg)
1.	Amaranth	12	1.36	.015	3	.45	.71	43.65	40.95	7.95
2.	Mustard	52	3.01	.033	8	.79	.66	58.74	103.95	37.62
	Kangkong	61	1.86	.020	5	.60	1.20	23.20	65.40	9.60
3.	Chinese leek	92	5.03	.055	13	1.65	1.21	47.85	238.15	19.25
	Chinese leek flower	92	.23	.003	1	.08	.07	.76	6.10	1.10
4.	Kang kong	34	3.29	.036	4	1.08	2.16	47.76	117.72	17.28
	Pai-tsai	45	2.10	.023	5	.41	1.10	34.04	40.94	17.02
5.	Pai-tsai	15	.66	.007	3	.13	.34	10.36	12.46	5.18
	Amaranth	39	3.13	.034	6	1.02	1.60	98.94	92.82	18.02
	Welsh onion	36	.82	.009	2	.13	.11	7.76	29.10	3.47
6.	Sweet pepper	92	4.92	.053	29	.69	.48	6.36	154.55	54.59
	Amaranth	22	1.49	.016	3	.48	.75	46.56	43.68	8.48
7.	Amaranth	14	3.19	.035	4	1.05	1.65	101.85	95.55	18.55
	Rape green	48	1.91	.021	4	.44	1.22	30.24	86.73	10.06
	Mustard	48	1.10	.012	4	.29	.24	21.36	37.80	13.68
8.	Kang kong	28	2.41	.026	3	.78	1.56	30.16	85.02	12.48
	Kale	78	1.37	.015	4	.36	.50	34.95	37.50	17.25
9.	Carrot	6	3.06	.033	3	.33	.70	11.88	536.91	3.40
	Ching chiang	53	2.31	.025	5	.63	.85	52.00	99.50	21.43
	Rape green	50	1.52	.017	4	.36	.99	24.48	70.21	8.14
Fence										
	Onion		.60	.007	1	.10	.09	5.03	22.63	2.70
	Sweet potato tips		1.89	.021	8	.84	2.40	28.92	26.25	9.95
	Yard-long bean		11.85	.129	28	3.61	2.32	65.79	42.96	36.12
	Shallot		3.05	.033	10	.69	.66	34.32	42.24	4.32
	Papaya		1.50	.016	3	–	–	–	35.20	5.13
	Mango		1.49	.016	3	.10	.05	1.60	50.13	5.76
	Cucumber		.37	.004	2	.02	.01	.56	.10	.28
Total			65.52	.714	168	17.11	23.63	870.12	2214.55	368.81
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						11.48	48.22	28.07	84.36	263.44

Table 24. Yield and nutrient contribution of Vitamin A Home Garden IV, September to November 1984, AVRDC.

Plot	Crop	Growing Period (days)	Edible Yield (kg)	Edible Yield/Day (kg)	Times Harvested	Nutrient Yield/Day				
						protein (g)	iron (mg)	calcium (mg)	Vitamin A (μg. RE)	Vitamin C (mg)
1.	Taro (stem)	46	1.70	.019	1	.42	.23	6.46	–	1.52
	Taro (stalk)	46	.52	.006	1	.03	.05	2.94	1.80	.78
2.	Amaranth	52	1.18	.013	3	.39	.61	37.83	35.49	6.89
	Rape green	37	5.29	.058	8	1.22	3.36	83.52	239.54	27.78
3.	Chinese leek	66	2.76	.030	5	.90	.66	26.10	129.90	10.50
	Chinese leek flower	66	.60	.007	5	.18	.15	1.78	14.23	2.58
	Lettuce	59	2.10	.023	5	.39	1.56	21.16	102.81	5.52
4.	Basil	32	1.62	.018	9	.59	.86	57.60	135.00	4.86
	Rape green	30	2.26	.025	4	.53	1.45	36.00	103.25	11.98
	Lettuce	30	1.28	.014	4	.24	.95	12.88	62.58	3.36
5.	Pai-tsai	18	1.18	.013	3	.23	.62	19.24	23.14	9.62
	Yard-long bean	62	4.50	.050	11	1.40	.90	25.50	16.65	14.00
6.	Mustard	57	9.52	.105	13	2.52	2.10	186.90	330.75	119.70
	Lettuce	29	1.29	.014	2	.24	.95	12.88	62.58	3.36
7.	Mustard	12	2.40	.026	3	.62	.52	46.28	81.90	29.64
8.	Kale	15	1.35	.015	3	.36	.50	34.95	37.50	17.25
	Pai-tsai	70	1.74	.019	3	.34	.91	28.12	33.82	14.06
	Kang kong	57	1.53	.017	3	.51	1.02	19.72	55.59	8.16
9.	Kale	80	3.29	.036	8	.86	1.19	83.88	90.00	41.40
Fence										
	Cucumber	91	.40	.004	3	.02	.01	.56	.10	.28
	Sweet potato tips	91	.82	.009	3	.36	1.03	12.39	11.25	4.26
	Mungo	91	1.16	.013	2	.08	.04	1.30	40.73	4.68
	Papaya	91	12.52	.138	19	–	–	–	303.60	44.27
	Taro (stem)	91	.44	.005	1	.11	.06	1.70	–	.40
	Taro (stalk)	91	.15	.002	1	.01	.02	.98	.60	.26
	Pumpkin	91	7.73	.085	9	.49	.62	2.79	331.50	4.62
Total			69.33	.764	135	13.04	20.37	763.46	2244.31	391.73
RDA for a family of five						149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)						8.75	41.57	24.63	85.50	279.81

Table 25. Results from four AVRDC home gardens means over four seasons, December 1983 through November 1984.

	Yield/Day (kg)	Percentage Contribution to RDA of a Family of Five[z]				
		protein	iron	calcium	Vitamin A	Vitamin C
Indonesia garden	0.947	12.83	73.23	39.74	95.08	369.81
Thailand garden	1.035	17.94	82.33	41.57	125.33	362.15
Philippine garden	0.957	13.55	69.36	38.81	81.97	374.44
Vitamin A garden	0.855	11.42	55.60	32.67	111.49	336.11

[z]RDA = Recommended daily dietary allowance

Table 26. Yearly yield and nutrient contribution of the urban home garden, August 1983 to August, 1984.

Crop	Edible Yield (kg)	Edible Yield / Day (kg)	Times Harvested	Nutrient Yield / Day				
				protein (g)	iron (mg)	calcium (mg)	Vitamin A (ug, RE)	Vitamin C (mg)
Kang kong	11.46	.029	34	.87	1.74	33.64	94.83	13.92
Spinach	3.25	008	10	.21	.24	7.28	43.44	3.30
Lettuce	10.46	.026	32	.44	1.77	23.92	116.22	6.24
Ching Chiang	9.78	.025	30	.63	.85	52.00	99.50	21.43
Rape green	9.62	.024	30	.50	1.39	34.56	99.12	11.50
Kale	5.09	.013	16	.31	.43	30.29	32.50	14.95
Mustard	10.13	.026	33	.62	.52	46.28	81.90	29.64
Amaranth	6.47	.016	21	.48	.75	46.56	43.68	8.48
Pai-tsai	12.26	.031	37	.56	1.49	45.88	55.18	22.94
Garland chrysanthemum	4.06	.010	20	.15	.27	7.60	43.80	1.69
Leaf beet	1.62	.004	7	.07	.19	1.78	6.53	.11
Chinese leek	7.64	.019	41	.57	.42	16.53	82.27	6.65
Celery	3.90	.010	14	.05	.12	7.70	1.33	1.70
Chinese cabbage	1.25	.003	1	.05	.08	3.06	11.53	1.59
Total	96.99	.244	326	5.51	10.26	357.08	811.83	144.14
RDA for a family of five				149.00	49.00	3100.00	2625.00	140.00
RDA contributed by garden (%)				3.70	20.94	11.52	30.93	102.96

Table 27. Yield and price record of market garden I, July to September 1983.

Plot	Crop	Growing Period (days)	Times Harvested	Marketable Yield (kg)	Market Price (NT$)	Gross Returns (NT$/kg)
1-2	Bitter melon	18	4	11.0	77.0	7.00
	Pai-tsai	24	1	26.5	235.0	8.87
	Kang kong	24	2	84.5	341.0	4.04
3-4	Pai-tsai	6	1	11.0	75.0	6.82
	Welsh onion	60	2	40.0	685.0	17.13
5-6	Sponge gourd	15	3	4.5	51.0	11.33
	Kang kong	24	2	60.0	333.0	5.55
	Pai-tsai	46	2	17.5	115.0	6.57
7-8	Welsh onion	12	4	80.5	2144.0	26.63
	Kang kong	21	2	75.0	365.0	4.87
	Chinese cabbage	40	1	9.0	13.0	1.44
9-10	Kang kong	28	4	109.0	506.0	4.64
	Pai-tsai	32	2	44.0	162.5	3.69
11-12	Yard-long bean	46	1	1.8	5.5	3.06
	Amaranth	34	1	23.5	170.0	7.23
Total			32	597.8	5278.0	

Table 28. Yield and price record of market garden II, October to December 1983.

Plot	Crop	Growing Period (days)	Times Harvested	Marketable Yield (kg)	Market Price (NT$)	Gross Returns (NT$/kg)
1-2	Yard-long bean	50	7	25.0	502.0	20.08
3-4	Chinese cabbage	12	2	38.8	552.0	14.23
	Garland chrysanthemum	71	3	22.0	199.0	9.05
	Sweet pepper	74	1	5.0	16.0	3.20
5-6	Chinese cabbage	26	1	41.5	581.0	14.00
	Broccoli	57	3	36.5	119.0	3.26
7-8	Pai-tsai	46	3	81.0	422.0	5.21
	Broccoli	33	1	7.5	245.0	32.67
	Eggplant	54	1	2.0	3.0	1.50
9-10	Pai-tsai	11	1	16.0	144.0	9.00
	Broccoli	59	5	28.0	406.0	14.50
11-12	Kang kong	18	2	38.5	375.0	9.74
	Cauliflower	68	3	57.5	288.0	5.01
13	Chinese leek	92	1	10.0	200.0	20.00
Total			34	409.3	4052.0	

Table 29. Yield and price record of market garden III, January to March 1984.

Plot	Crop	Growing Period (days)	Times Harvested	Marketable Yield (kg)	Market Price (NT$)	Gross Returns (NT$/kg)
1-2	Mustard	6	1	12.0	12.0	1.00
	Broccoli	30	3	26.5	79.0	2.98
	Spinach	38	1	55.5	233.0	4.20
3-4	Sweet pepper	25	3	19.0	110.0	5.79
	Kohlrabi	20	2	36.0	103.0	2.86
	Celery	56	2	88.0	858.0	9.75
5-6	Spinach	45	2	52.5	297.0	5.66
	Kang kong	48	2	24.0	129.0	5.38
7-8	Eggplant	39	5	26.0	91.0	3.50
	Kang Kong	52	1	22.5	97.0	4.31
9-10	Garland chrysanthemum	45	3	76.0	443.0	5.83
	Spinach	36	2	29.5	708.0	24.00
11-12	Mustard	20	1	24.0	24.0	1.00
	Celery	56	3	64.0	436.0	6.81
13	Chinese leek	91	2	40.0	479.0	11.98
Total			33	595.5	4099.0	

Table 30. Yield and price record of market garden IV, April to June 1984.

Plot	Crop	Growing Period (days)	Times Harvested	Markstable Yield (kg)	Market Price (NT$)	Gross Returns (NT$/kg)
1-2	Kang kong	20	2	43.0	262.0	6.09
	Yard-long bean	65	1	2.0	29.0	14.50
3-4	Amaranth	25	3	52.4	451.0	8.61
	Kang kong	28	1	40.5	138.5	3.42
5-6	Broccoli	47	3	23.9	348.5	14.56
	Rape green	32	2	40.8	260.5	6.38
7-8	Yard-long bean	61	3	12.0	155.0	12.92
	Amaranth	23	1	29.1	274.0	9.42
9-10	Kang kong	24	2	45.5	303.0	6.66
	Mustard	35	1	10.0	72.0	7.20
11-12	Amaranth	19	2	37.5	290.0	7.73
	Kang kong	30	1	32.7	161.0	4.92
13	Chinese leek	91	2	40.0	379.0	9.48
Total			24	409.4	3389.5	

Table 31. Yield and profit of AVRDC market gardens July 1983 through June 1984.

	Marketable Yield (kg)	Wholesale Market Price (NT$)	Cash Cost[z] (NT$)	Profit (NT$)
Garden I	597.8	5278	513	4765
Garden II	409.3	4052	454	3598
Garden III	595.5	4099	438	3661
Garden IV	409.4	3389	213	3176
Total	2012.0	16818	1618	15200
Net wholesale profits				(US$385)

[z]Cash cost includes the cost of seeds, pesticide, and chemical fertilizer.

New Vegetable Project

Evaluation of Commercial Cultivars of Five Vegetable Crops

Introduction

In view of the diversity of vegetables common to the tropics, the Center has initiated a program to evaluate commercial cultivars of five vegetables which were developed in the temperate countries since 1982. In the first phase of these project, a total of 646 commercial cultivars of five vegetables (sweet and hot peppers, snap bean, mustard, cauliflower, and radish) introduced from 17 countries were evaluated in six observational and two advanced trials at AVRDC by 1984 (Table 1). The results of the final trial conducted for the selected entries during summer 1984 are presented with brief summaries of the previous trials here in this report.

The overall objectives of the entire project are the following:

1. To evaluate the yield and horticultural characteristics of commercially available cultivars under tropical environments)
2. To identify major production constraints and potential for future development of the five vegetables
3. To generate information for use in AVRDC's nutrition garden projects and bilateral programs, and by the Center's cooperators in Southeast Asia
4. To broaden the focus of AVRDC research and training programs so they encompass a wider range of vegetables.

Table 1. Number of cultivars evaluated, seed sources, and cultivars selected.[2]

Crops	No. of Cultivars Evaluated	Seed Source		No. of Cultivars Selected
		no. of countries	no. of seed suppliers	
Cauliflower	122	9	34	16
Mustard	41	7	18	7
Sweet pepper	126	8	37	9
Hot pepper	96	12	16	12
Radish	107	10	45	15
Snap bean	154	9	36	19
Total	646	(17)	(65)	78

[2]From Feb. 1982 to March 1983.

Materials and Methods

As of December 1984, a total of 62 separate trials, including 45 observational and 17 replicated trials, have been conducted since the beginning of the project in February 1982.

Among them, only 40 trials were successful; the rest were destroyed by typhoons, heavy rains or other constraints, such as poor germination or diseases. In general, each cultivar was evaluated in three seasons (spring, summer, and fall) for one or two years before the replicated trials for final evaluation where entries were selected based on their overall performance in previous observational trials.

In 1982 and 1983, 78 cultivars (12%) were selected for final evaluations, once in the cool-dry season in fall 1983 and once in the hot-wet season in summer 1984. The planting and harvesting dates as well as number of the entries in the replicated trials in summer 1984 are summarized in Table 2.

Table 2. Replicated variety trials of five vegetables in the hot-wet season of 1984.

Crops	Entry No.	Rep. No.	Plot Size (plant no./ plot)	Date Sown	Date Planted	Date Harvested	Duration (days)
Hot pepper	12	4	24	04-16-84	05-24-84	08-2-84/ 09-5-84	105
Sweet pepper	11	4	24	04-16-84	05-24-84	07-13-84/ 08-28-84	96
Cauliflower	16	4	24	04-16-84	05-11-84	06-19-84/ 07-5-84	56
Mustard	7	4	24	04-16-84	05-11-84	06-13-84/ 06-14-84	35
Snap bean (bush type)	11	4	48	07-27-84	–	–	–
Snap bean (pole type)	5	4	48	07-27-84	–	10-5-84/	79
Radish	17	4	48	07-13-84	–	08-29-84/	56

Results

Cauliflower (*Brassica oleracea* var. *botrytis*). A total of 16 were selected from 122 cultivars for final evaluation in the replicated trial conducted during the hot-wet period from May 11 to July 5, 1984. Some cultivars appeared to be quite promising for production in the tropical lowland conditions. Chia Tai No. 1 from Thailand produced 6.6 t/ha of marketable curd and had very little incidence of soft and black rots (Tables 3 and 5). Mean head size was 343 g, and heading rate was as high as 98%. The Japanese Mikado 40 Days and the Taiwanese F1 451 performed equally well in yield of marketable curds and low soft rot infection. Black rot was serious even with these best performing entries (Table 5).

It is important to note that these entries showed curd yield and heading rate close to those in cool seasons, if the marketable yield was much lower. Low marketable yield was attributed mainly to the high incidence of curd breakdown or bract (leafy curd) growth. I addition, some F1's were either not high enough in heading rate or not uniform enough in head size and head shape (Tai Nong Hybrid 45 Days and Fengshan Extra Early).

In general, the early cultivars had much better resistance to high tmperature in terms of heading ability. Chia Tai No. 1, F1 451, and Mikado 40 Days had the earliest maturity dates (around or less than 40 days) and were also the best yielders (Table 3). There were drastic differences in heading ability among varieties in different environments. For example, Snow Comet yielded very well during the cool-dry season, but did not produce any curds in the hot-wet season (Table 4).

In addition to the requirement of heat-tolerant cultivars, the major production constraint of cauliflower under hot-wet environments was disease, especially black and soft rots. The early-maturing cultivars, however, were relatively more able to escape black rot owing to their short growing period (Table 5). Most of the early cultivars also had less incidence of soft rot; however, it was difficult to say whether it was due to varietal resistance or timely escape.

Table 3. Total and marketable yields of cauliflower cultivars evaluated in advanced yield trial in summer, 1984[z]

Coll. No.	Cultivar Name	Overall Rating	Yield (t/ha)[y]		Origin	
			total	marketable	company/institute	country
1	Fengshan Extra Early	B	10.2cde	4.4bcd	Known You Co.	Taiwan
7	Tai Nong Hybrid 45 Days	B+	13.7abc	4.8abc	Taiwan Nong Tsan	Taiwan
13	F_1 Zu-Kwang 50 Days	C	6.6e	1.9e	Hsing Nong Co.	Taiwan
15	Summer Earliest 40 Days	B	9.1de	2.9de	Fu Nong Co.	Taiwan
26	F_1 451 (40 Days)	A+	15.6ab	6.3a	Cheng Wen Chiang	Taiwan
27	F_1 402 (45 Days)	A	12.3bcd	4.4bcd	Cheng Wen Chiang	Taiwan
34	T.S.S. No. 1	B	16.3ab	5.8ab	Taiwan Seed Service	Taiwan
37	Mikado 40 Days	A	16.8a	6.5a	Mikado Co.	Japan
39	Mikado 50 Days	C+	11.0cd	2.9de	Mikado Co.	Japan
40	Mikado 55 Days	C	0.0f	0.0f	Mikado Co.	Japan
44	Snow Queen	C+	11.0cd	3.2cde	Takii & Co.	Japan
68	Kibo Reuzen R.S.	C	0.0f	0.0f	Royal Sluis	Netherland
72	Piracicaba de Verao	C	0.8f	0.2f	Embrapa/Cenargen	Brazil
80	Chia Tai # 1	A	17.6a	6.6a	Chia Tai Co.	Thailand
81	Snow Comet	C	0.0f	0.0f	HeungNong Co.	Korea
106	Santa Elisa No.2	C	0.3f	0.0f	Embrapa/Cenargen	Brazil

[z]Date sown: April 16, 1984; date transplanted: May 11, 1984; date harvested: June 19 to July 5, 1984; experimental design: RCBD, four replications. [y]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 4. Performance of selected cauliflower cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Entry Name	Marketable Curd Yield(t/ha)						Mean[x] HT (%)
	1982		1983		1984	Mean	
	sp[z]	fall[z]	sp[z]	fall[y]	su[y]		
Fengshan Extra Early	8.2	8.0	7.5	11.5	4.4	7.9	44.9
Tai Nong Hybrid 45 Days	10.0	9.3	8.4	13.2	4.8	9.1	42.1
F_1 Zu-Kwang 50 Days	11.6	13.9	8.3	20.3	1.9	11.2	11.1
Summer Earlist 40 Days	10.4	5.3	7.7	13.6	2.9	8.0	30.5
F_1 451(40 Days)	7.6	9.3	8.3	16.2	6.3	9.5	49.2
F_1 402(45 Days)	10.9	10.5	9.7	–	4.4	8.9	41.9
T.S.S. No. 1	6.3	9.7	8.3	13.0	5.8	8.6	50.9
Mikado 40 Days	8.2	14.4	6.9	15.5	6.3	10.3	43.3
Mikado 50 Days	5.0	10.0	5.5	11.2	2.9	6.9	27.4
Mikado 55 Days	3.9	22.2	–	14.2	0.0	10.1	0.0
Snow Queen	7.1	12.5	8.3	15.0	3.2	9.2	23.2
Kibo Reuzen R.S.	3.6	13.7	–	16.4	0.0	8.4	0.0
Piracicaba de Verao	6.8	17.0	–	16.9	0.2	10.2	1.2
Chia Tai #1	6.6	13.7	–	15.1	6.6	10.5	45.8
Snow Comet	6.2	21.0	–	17.7	0.0	11.2	0.0
Santa Elisa No.2	–	17.7	–	16.6	0.0	11.4	0.0
Mean	7.5	13.0	7.9	15.1	3.1	9.5	
All entry mean	5.9	10.0	6.0	15.1	3.1	7.7	

[z]Observational trials with no replication. [y]Advanced trials, replicated four times. [x]Mean heat-tolerance rating = mean yield of summer trials/mean yield of fall trials × 100%.

In general, some of the commercial cultivars appeared to be quite promising for production under hot-wet environments. Cultivars marked as A or A$^+$ in overall rating in Table 3 are recommended for further testings in the national programs of Southeast Asia.

Mustard (*Brassica juncea*). Seven cultivars were selected from 41 entries for final evaluation in the replicated trials conducted during the hot-wet season in 1984 (Table 6). Among them, three belong to the heading type, and four to the leafy type. In previous trials

Table 5. Horticultural characteristics of cauliflower cultivars evaluated in advanced yield trials in summer, 1984[z]

Coll. No.	Cultivar Name	Mean						Heading Rate (%)	Black Rot (%)	Soft Rot (%)
		Plant Weight (g)	Head[y] Cover	Stand (no/plot)	Head Weight (g)	Head Length (cm)	Head Width (cm)			
1	Fengshan Extra Early	625	F	23.5	255	9.5	13.7	88.5	52.1	15.8
7	Tai Nong Hybrid (45 Days)	660	P	24.0	260	9.9	15.4	99.0	79.2	0.0
13	F_1 Zu-Kwang 50 Days	885	F	24.0	428	12.0	18.9	36.5	63.3	22.9
15	Summer Earliest 40 Days	628	F	24.0	235	9.6	12.1	68.8	70.8	16.6
26	$F_1$2451 (40 Days)	610	F	24.0	273	9.4	14.7	95.8	74.8	4.2
27	F_1 402 (45 Days)	733	G	24.0	263	9.2	12.5	77.1	38.5	19.8
34	T.S.S. No. 1	718	F	24.0	270	9.6	16.3	94.8	69.8	2.1
37	Mikado 40 Days	787	F	23.8	345	11.1	15.7	96.8	75.5	0.0
39	Mikado 50 Days	608	F	23.3	243	11.3	13.7	85.9	71.6	13.8
40	Mikado 55 Days	–	–	24.0	–	-	–	0.0	65.1	15.6
44	Snow Queen	580	F	23.8	190	7.6	12.8	93.8	90.6	11.8
68	Kibo Reuzen R.S.	920	G	22.8	460	10.6	16.6	0.0	89.5	42.5
72	Piracicaba de Verao	–	–	22.5	–	–	–	5.8	78.1	19.1
80	Chia Tai # 1	758	F	24.0	343	10.4	16.9	97.9	62.5	1.0
81	Snow Comet	–	–	23.8	–	–	–	0.0	67.1	58.8
106	Santa Elisa No. 2	–	–	23.5	–	–	–	1.1	26.7	6.3

[z]Date transplanted: May 11, 1984; date harvested: June 19 to July 5, 1984; experimental design: RCBD, four replications. [y]G = good, F = fair; P = poor.

Table 6. Total and marketable yield of mustard cultivars evaluated in advanced yield trials in summer, 1984[z]

Coll. No.	Cultivar Name	Overall Rating	Type	Yield (t/ha)[y]		Company/ Institute	Country
				total	marketable		
7	Chih Yeh Pao Shin	C$^+$	heading	21.8a	2.4d	Fong Tien Co.	Taiwan
23	Mustard Green	C	heading	18.3abc	1.6d	Chia Kwang Seng R.O.P.	Thailand
25	Giant Curled	C	leafy	8.1d	6.0bc	Watanabe Co.	Japan
26	Embrapa/Cenargen No. 1	B$^+$	leafy	16.4bc	13.1a	Embrapa/ Cenargen	Brazil
30	Crespa	B$^+$	leafy	11.1d	8.2b	Embrapa/ Cenargen	Brazil
35	Chinese Mustard	C	heading	20.0ab	3.3cd	Chia Tai Co.	Thailand
36	Tendergreen	B	leafy	15.9c	12.0a	Abbott & Cobb	U.S.A.

[z]Date sown: April 16, 1984; date transplanted: May 11, 1984; date harvested: June 13 to 14, 1984; experimental design: RCBD, four replications. [y]Mean separation within columns by Duncan's multiple range test at 5% probability level.

conducted during the hot-wet seasons in 1982 and 1983, these three heading mustards (Chih Yeh Pao Shin, Mustard Green, and Chinese Mustard) yielded mostly more than 10 t/ha of marketable heads. Their overall mean head yield during the hot and cool seasons in the past three years was around 13 t/ha (Table 7).

The leafy mustards were, in general, more promising for lowland production in the tropics (Table 7). The smaller difference in their summer yield from that of cool seasons indicated better adaptability of these cultivars for production under the hot-wet environments.

The bolting rate of the leafy cultivars was much less than that of the heading types, all of which were susceptible to bolting (Table 8). In addition to low heading rate and bolting, soft rot and turnip mosaic virus were found to be the major production constraints during the hot-wet season. None of the cultivars of both types were consistently tolerant to these two diseases in three years of trials.

Snap bean (*Phaseolus vulgaris*). Among 154 cultivars being evaluated since spring 1982, 25 were pole-type and 129 were bush-type snap beans. A total of seven separate trials were conducted since 1982, but only four were successful (two in spring and one each in fall and summer). The only successful trial during the hot-wet season was the trial conducted in summer of 1984. The bush-type snap beans did not germinate well and were attacked by soil-borne fungi; so no information is available on their performance in the hot-wet season (Table 11).

Table 7. Performance of selected mustard cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Entry Name	Marketable Yield(t/ha)								Mean[x] HT (%)
	1982			1983			1984	Mean	
	sp[z]	su[z]	fall[z]	sp[z]	su[z]	fall[y]	su[y]		
Chih Yeh Pao Hsin	24.0	22.2	4.6	10.3	8.7	21.5	2.4	12.9	105.3
Mustard Green	19.0	17.7	5.3	17.2	7.2	20.5	1.6	12.6	96.9
Giant Curled	8.8	11.7	–	4.2	6.1	16.7	6.0	8.9	53.3
Embrapa/Cenargen No.1	22.0	10.7	11.0	9.8	9.6	30.2	13.1	15.2	49.5
Tendergreen	15.0	12.0	3.0	7.0	6.6	32.3	–	12.7	52.5
Crespa	12.0	15.0	2.0	7.0	7.2	21.6	8.2	10.4	98.2
Chinese Mustard	25.0	17.0	5.0	7.0	10.7	18.3	3.3	12.3	118.8
Tendergreen	–	9.8	8.4	16.0	5.7	–	12.0	10.4	92.9
Mean	18.0	14.1	5.6	9.8	7.7	23.0	6.7	11.9	
All entry mean	17.2	12.6	5.7	7.8	8.2	23.0	6.7	10.0	

[z]Observational trials with no replication [y]Advanced trials, replicated four times. [x]Mean HT (mean heat-tolerance rating) = mean yield of summer trials/mean yield of fall trials × 100%.

Table 8. Horticultural characteristics of mustard in advanced yield trials in summer, 1984[z]

Coll. No.	Cultivar Name	Plant Weight (g)	Head Weight (g)	Head Length (cm)	Head Width (cm)	No. Leaf/ Plt.	Heading Rate (%)	Bolting Rate (%)	Disease(%)	
									soft rot	TuMV
7	Chih Yeh Pao Shin	–	175	9.9	8.1	22.1	61.4	38.6	10.9	11.9
23	Mustard Green	–	160	8.0	7.2	18.3	45.7	54.3	9.7	33.0
25	Giant Curled	435	–	–	–	27.7	0.0	0.0	17.5	22.8
26	Embrapa/Cenargen No. 1	795	–	–	–	16.6	0.0	1.1	9.1	62.4
31	Crespa	565	–	–	–	59.4	0.0	5.7	8.8	16.4
35	Chinese Mustard	–	166	8.1	7.6	19.3	36.2	63.8	8.3	44.8
36	Tedergreen	780	–	–	–	62.2	0.0	0.0	23.6	97.3

[z]Date sown: April 16, 1984; date transplanted: May 11, 1984; date harvested: June 13 to 14, 1984; experimental design: RCBD, four replications

Five pole-type cultivars were selected from 25 entries for final evaluation under the hot-wet environment of summer 1984. Among them, Cultivars Witsa (South Africa) and Black Creasback Yuang Ching (Taiwan) produced 17 t/ha of marketable pods in less than three months of growing period (Tables 9, 12). Their yield ranged from 21 to 23 t/ha in the cool-dry fall season. These two cultivars were promising for production in the tropics. Cultivar Witsa is white-seeded, and Black Creasback is black-seeded. They both produce light green colored pods weighing 7 to 8 g/pod (Table 10). Witsa is a stringless cultivar, and its eating quality is rated higher than Black Creasback.

Most cultivars were susceptible to rust, the biggest problem in snap bean production. Seed viability was also difficult to maintain in hot-humid environments.

Sweet pepper (*Capsicum annum* L.). Of the 126 cultivars introduced from 37 seed companies or institutes of eight countries, only nine cultivars were selected for final evaluation in the hot-wet season of 1984. Some temperate cultivars performed surprisingly well in the hot-wet environment. Cultivar Gypsy (USA) produced up to 36 t/ha of marketable fruits in a replicated summer trial in 1984 (Table 13). The mean yield of this cultivar in the hot-wet season during the past two years was 25.1 t/ha compared to 18.6 t/ha in the cool-dry fall season.

Green Boy (Japan) yielded 39 t/ha in summer 1984 with a mean of 25.5 t/ha in the hot seasons. Most of the Californian and European cultivars failed to produce fruits under extreme high temperature. Belle Star, Resistant Florida Giant, Yolo Wonder B, yielded high only during cool-dry seasons (Table 14).

Table 15 shows the fruit and horticultural characteristics of the selected sweet pepper cultivars. None of the thick-walled, large, green-fruited cultivars seemed less desirable during the hot-wet season.

Table 9. Marketable yield of snap bean cultivars evaluated in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Overall Rating	Pod Yield (t/ha)	Origin		Growth Habit
				company/institute	country	
2	Pai Chia 7"	B	16.1	Nong Seng Co.	Taiwan	Pole type
11	Heh Jen 4"	B	13.7	FTHES[y]	Taiwan	"
16	Black Creasback (Yuang Ching)	B+	17.2	Taichung DAIS	Taiwan	"
18	Black Creasback (Hsing Sher)	C+	14.7	Taichung DAIS	Taiwan	"
53	Witsa	A	16.9	C & May Co.	Africa	
	LSD		NS			

[z]Date sown: July 27, 1984; date harvested: Oct. 5 and 18, 1984. [y]Fengshan Tropical Horticulture Experiment Station.

Table 10. Horticultural characteristics of snap bean cultivars evaluated in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Pod Characteristics				Flower Color	Seed Color
		color	weight (g)	length (mm)	width (mm)		
2	Pai Chia 7"	Green	7.1	137	10	Pink	Black
11	Heh Jen 4"	Green	6.6	119	11	Pink	Black
16	Black Creasback (Yuang Ching)	Green	8.1	135	10	Pink	Black
18	Black Creasback (Hsing Sher)	Green	7.0	129	11	Pink	Black
53	Witsa	Green	9.5	163	12	White	White

[z]Date sown: July 27, 1984; date harvested: Oct. 5 and 18, 1984; experimental design: RCBD, four replications.

The major diseases identified were southern blight and bacterial wilt. Almost all plants were infected by one or more kinds of viruses (tobacco mosaic virus, cucumber mosaic virus, potato virus y, tobacco etch virus, and pepper mottle virus) by the late growing period. The viruses seemed to be the most serious problem for production in the tropics. Proper rotation and selection of soil types could help decrease these diseases.

Hot pepper (*Capsicum annuum* L.). Among the five species of vegetables tested for adaptation in the tropics with the commercially available cultivars, hot pepper grew best. They were generally resistant to heat, saturated soil moisture, diseases, and pests. In the past three years, 96 hot pepper cultivars from 16 seed sources in 12 countries have been screened for production under various environments in seven consecutive experiments at AVRDC. Six trials were successful; two in the wet season and four in the dry season (Table 16).

Table 11. Performance of selected bush-type snap bean cultivars in various growing seasons from 1982 to 1983 at AVRDC.

Coll. No.	Entry Name	Marketable Pod Yield(t/ha) 1982 spring[z]	1982 fall[z]	1983 fall[y]	mean	Seed Source
4	Stringless	13.7	4.1	9.6	9.1	Taiwan Nong Tsan, Taiwan
29	Satsukimidori No.2	17.7	4.7	7.8	10.1	Takii & Co., Japan
38	Blue Beach	17.2	3.1	9.1	9.8	Kyowa Co., Japan
63	BEF R.S.	12.0	4.9	11.2	9.4	Royal Sluis, Netherland
70	RS 1301 (CIMBOLA)	14.3	5.2	6.8	8.8	Royal Sluis, Netherland
79	Admires	19.3	4.6	8.7	16.3	Zealand Seeds,Netherland
81	Cascade	20.8	3.3	11.5	11.9	Agrigenetics Corp.,USA
84	Raider	16.7	4.5	10.7	10.6	Agrigenetics Corp.,USA
92	Jolanco	–	5.5	7.9	6.7	Nunhems Zaden,Netherland
97	Felitop	–	4.8	8.4	6.6	Zwaan and Zoon,Netherland
144	Provider	–	–	8.6	8.6	Agrigenetics Corp., USA
152	Gator Green 15	–	–	9.6	9.6	Ferry-Morse Co., USA
153	Producer (E-8268)	–	–	8.1	8.1	Ferry-Morse Co., USA
Mean		16.5	4.5	9.1	9.7	
All entry mean		14.6	4.3	12.3	9.3	

[z]Observational trials, not replicated. [y]Advanced trials, replicated four times.

Table 12. Performance of selected pole-type snap bean cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Coll. No.	Entry Name	Marketable Pod Yield(t/ha) 1982 sp[z]	1983 sp[z]	1983 fall[y]	1984 su[y]	mean	Mean[x] HT (%)	Estimated[w] Summer Yield (t/ha)	Rating
2	Pai Chia 7 inch	20.0	2.7	22.5	16.1	15.3	71.5	16.1	3
11	Heh Jen 4"	14.0	8.6	23.2	13.7	14.9	59.1	13.7	4
16	Black Creasback (Yuang Ching)	17.8	14.9	23.4	17.2	18.2	73.5	17.2	2
18	Black Creasback (Hsin Sher)	23.5	4.2	–	14.7	14.1	–	–	
53	Witsa	29.7	3.4	21.2	16.9	17.8	79.7	23.7	1
Mean		21.0	6.8	22.6	15.7	16.1			
All Entry Mean		18.4	6.0	22.6	15.7	11.9			

[z]Observational trials, not replicated. [y]Advanced trials, replicated four times. [x]Mean HT (mean heat tolerance rating) = mean yield of summer trials/mean yield of fall trials × 100%. [w]Estimated hot-season yield potential = highest record yield of the cultivar × mean HT.

The final trial was conducted from May 24 to September 5, 1984 at AVRDC on 12 cultivars selected from the previous trials. Among them, three cultivars yielded more than 20 t/ha of marketable chilies in about one month of harvest period. Cultivar Passion (Taiwan) yielded high (23.4 t/ha) of marketable fruits, and scored well on appearance and hotness (Tables 17 to 18). It was, however, susceptible to phomopsis fruit rot in the wet season.

Farmers Newcomer, another Taiwanese cultivar, also produced well and had large fruits, but it was not pungent. Hungarian Wax (USA) had yellow-skinned large hot fruits and was promising for production in the hot-wet season. It had a determinate growth habit and early maturity with fruits suitable for the fresh market.

Table 13. Total and marketable yields of sweet pepper cultivars in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Overall Rating	Yield(t/ha)[y] total	Yield(t/ha)[y] marketable	Origin company/institute	Country
1	Blue Star	B	20.7a	20.0b	Known You Co.	Taiwan
20	Citadel	C	7.5c	7.4c	Peto Seeds Co.	USA
21	Gypsy	A+	37.3a	35.9a	Peto Seeds Co.	USA
23	Dalbon	B−	19.7b	19.1b	Peto Seeds Co.	USA
50	California Wonder	C	5.7c	5.5c	Royal Sluis co.	Netherland
95	Cubanelle	B−	19.2b	18.7b	Agrigenetics Corp.	USA
98	Yolo Wonder B	C	2.5c	2.3c	Agrigenetics Corp.	USA
103	Green Boy	A	40.3a	38.9a	Kaneko Co.	Japan
115	Four Corners	C	9.2c	8.6c	Ferry Morse Co.	USA
116	Resistant Florida Giant	C	10.3c	9.3c	Ferry Morse Co.	USA
117	Belle Star	C	8.7c	8.2c	Ferry Morse Co.	USA

[z]Date sown: April 16 1984; date transplanted: May 25, 1984; date harvested: July 13 to August 28, 1984; experimental design: RCBD, four replications. [y]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 14. Performance of selected sweeet pepper cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Entry Name	Marketable Fruit Yield(t/ha) 1982 sp[z]	1982 fall[z]	1983 sp[z]	1983 su[z]	1983 fall[y]	1984 su[y]	Mean	Mean[x] HT (%)	Estimated[w] Summer Yield (t/ha)
Blue Star	4.2	13.0	9.1	16.4	24.8	20.0	14.6	96	23.9
Citadel	8.3	12.0	5.4	4.0	20.1	7.4	9.5	35	6.9
Gypsy	9.0	14.0	12.0	14.2	23.1	35.9	18.0	134	48.4
Dalbon	6.2	16.1	7.9	13.7	32.8	19.1	16.0	60	19.6
California Wonder	2.5	10.3	10.8	4.4	13.1	5.5	7.8	38	4.9
Cubanelle	–	5.1	7.8	14.2	18.0	18.7	12.8	142	26.6
Yolo Wonder B	–	4.2	9.3	2.9	26.5	2.3	9.0	17	4.5
Green Boy	–	–	12.0	19.7	22.4	38.9	23.3	130	50.1
Four Corners	–	–	–	–	22.3	8.6	15.5	39	8.6
Resistant Florida Giant	–	–	–	–	26.6	9.3	18.0	35	9.3
Belle Star	–	–	–	–	28.9	8.2	18.6	28	8.2
Mean	6.2	10.8	8.9	10.3	23.4	15.8	14.4		
All entry mean	4.4	8.5	7.5	8.7	23.4	15.8	11.4		

[z]Observational trials, no replication. [y]Advanced trials, replicated four times. [x]Mean heat-tolerance rating = mean yield of summer trials/mean yield of fall trials × 100%. [w]Estimated hot-season yield potential = highest record yield of the cultivar × mean HT.

Twist Hot (Korea) had good yield in summer and its fruits was good for drying. Hong Shan Ho (Korea) was another promising cultivar for summer production and was rated best in hotness.

Viruses, southern blight, and bacterial wilt caused serious yield reduction in hot pepper.

Table 15. Fruit and horticultural characteristics of sweet pepper cultivars evaluated in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Fruit Characteristics						Taste[y]
		fruit set rating	color	mean fruit size			wall thick-ness(mm)	
				wt (g)	length (mm)	width (mm)		
1	Blue Star	Fare	Dark Green	60.5	86	48	3.4	Excellent
20	Citadel	Very poor	Green	43.1	51	51	4.1	–
21	Gypsy	Excellent	L/Yellow	46.9	90	42	4.1	Poor
23	Dalbon	Poor-Fair	Green	64.6	95	52	3.5	Good
50	California Wonder	Poor	Green	45.0	57	50	3.9	–
95	Cubanelle	Fair	L/Green	33.4	107	32	3.0	Good
98	Yolo Wonder B	Poor	Green	50.4	53	53	3.2	–
103	Green Boy	Good	Green	39.7	95	41	2.6	Fair
115	Four Corners	Poor-Fair	Green	50.6	59	54	4.5	–
116	Resistant Florida Giant	Poor-Fair	Green	50.0	60	55	4.1	–
117	Belle Star	Poor-Fair	Green	48.4	54	55	4.3	–

[z]Date sown: April 16, 1984, date transplanted: May 25, 1984; date harvested: July 13 to August 28, 1984; experimental design: RCBD, four replications. [y]Only the selected entries were tested.

Table 16. Performance of selected hot pepper cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Entry Name	Marketable Fruit Yield(t/ha)							Mean[x] HT (%)
	1982		1983			1984	Mean	
	sp[z]	fall[z]	sp[z]	su[z]	fall[y]	su[y]		
Farmers Newcomer(F_1)	3.0	4.7	19.2	18.6	20.2	22.0	14.6	182.4
Passion	3.7	5.4	21.2	22.6	22.2	23.4	16.4	166.7
Young Chiao Chiao	3.3	4.3	4.8	2.1	11.6	3.2	4.9	33.8
672 Hungarian Wax	5.7	4.6	10.0	12.4	11.6	16.7	10.2	182.5
Bulam House Pepper	9.6	3.2	13.5	12.2	6.8	13.5	9.8	258.0
Early Spring Green	8.2	3.3	12.4	12.0	7.5	18.4	10.3	281.5
Hot Long	3.0	5.7	27.3	12.9	15.2	18.6	13.8	150.4
Twist Green	2.9	4.2	32.1	10.0	6.6	17.2	12.2	251.9
Hanulcho	3.3	3.5	14.2	9.5	7.5	9.7	8.0	174.5
Hong Shan Ho	4.2	6.1	31.0	14.7	13.1	24.0	15.5	202.1
Early to Coloring	3.0	4.1	30.0	15.0	10.0	15.2	12.9	212.7
Shin Shin House	3.2	4.0	34.3	16.4	13.5	13.7	14.2	171.6
Mean	4.4	4.4	20.8	13.2	12.2	16.3	11.9	
All entry mean	4.1	4.4	8.6	6.2	12.0	16.3	8.6	

[z]Observational trials, no replication. [y]Advanced trials, replicated four times. [x]Mean heat-tolerance rating = mean yield of summer trials/mean yield of fall trials × 100%.

Radish (*Raphanus sativus*). Fifteen radish cultivars were selected from 107 cultivars for final evaluation in summer 1984. Among them, Summer Top from Korea and 40 Days Early and Radish from Taiwan were identified to have potential for production in the hot-wet environments. (Tables 19, 20). In fact, most of the selected entries produced storage roots easily under hot-wet conditions.

The problem of most cultivars was the inability to produce uniform marketable roots. The harvest rate (no. of plants harvested per total plant no.) was also low, (Table 21). This was particularly true of the open-pollinated Taiwanese cultivars.

Other problems were root branching, hollow roots, and insect damage. The most severe pest was the diamondback moth. Poor standing also resulted from heavy rains which caused seed rot and often washed away seeds or seedlings.

Table 17. Total and marketable yields of hot pepper cultivars evaluated in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Overall Rating	Yield (t/ha)[y]		Origin	
			total	marketable	company/institute	country
1	Farmers Newcomer	A	23.2abc	22.0abc	Known You Co.	Taiwan
5	Passion	A⁻	25.5a	23.4ab	Known You Co.	Taiwan
6	Young Chiao Chiao	C	2.9f	3.2f	Taiwan Nong Tsan	Taiwan
11	672 Hungarian Wax	A	17.6cd	16.7cd	Celanese Co.	USA
13	Bulam House Pepper[x]	B⁻	14.3de	13.5de	HeungNong Co.	Korea
14	Early Spring Green	B⁻	18.9cd	18.4bcd	Choong Ang Co.	Korea
17	Hot Long	C⁺	19.2bcd	18.6bcd	HeungNong Co.	Korea
20	Twist Hot	B⁺	18.2cd	17.2cd	HeungNong Co.	Korea
21	Hanulcho	B⁺	10.3e	9.7e	HeungNong Co.	Korea
22	Hong Shan Ho	A⁻	24.6ab	24.0a	HeungNong Co.	Korea
25	Early to Coloring[x]	B⁻	15.7de	15.2d	Shin Shin Co.	Korea
26	Shin Shin House[y]	B	14.5de	13.7de	Shin Shin Co.	Korea

[z]Date sown: April 16, 1984; date transplanted: May 24, 1984; date harvested: August 2 to September 5, 1984; experimental design: RCBD, four replications. [y]Mean separation within columns by Duncan's multiple range test at 5% probability level. [x]Selfed seeds were used in these entries.

Table 18. Fruit and horticultural characteristics of hot pepper cultivars evaluated in advanced yield trials in summer, 1984[z]

Coll. No.	Cultivar Name	Fruit Characteristics						Growth[w] Habit
		fruit set rating	mean fruit size			wall thick-ness(mm)	hot-ness[x]	
			wt (g)	length (mm)	width (mm)			
1	Farmers Newcomer	Good	35.5	151	27	3.0	MH	Ind.
5	Passion	Good	17.5	121	19	2.4	H	Ind.
6	Young Chia Chia	Very poor	7.9	112	14	1.9	–	Ind.
11	672 Hungarian Wax	Excellent	37.2	130	30	3.2	H	Det.
13	Bulam House Pepper[y]	Good	11.8	112	17	1.8	VH	Ind.
14	Early Spring Green	Fair-Good	15.1	121	22	2.0	SH	Ind.
17	Hot Long	Fair	17.2	97	21	2.6	H	Ind.
20	Twist Hot	Good	9.2	86	19	1.4	H	Ind.
21	Hanulcho	Excellent	6.1	87	14	1.5	H	Det.
22	Hong Shan Ho	Good	15.2	105	19	2.1	VH	Ind.
25	Early to Coloring[y]	Good	14.0	101	20	2.1	H	Ind.
26	Shin Shin House[y]	Good	14.8	113	19	1.8	VH	Ind.

[z]Date sown: April 16, 1984; date transplanted: May 24, 1984, date harvested: Aug. 2 to Sept. 5, 1984; experimental design: RCBD, four replications. [y]Selfed seeds were used in these cultivars. [x]SH: slightly hot; MH = moderately hot; H = hot; VH = very hot. [w]Ind. = indeterminate type; Det. = determinate type.

Table 19. Total and marketable yields of radish cultivars evaluated in advanced yield trials in summer, 1984[z].

Coll. No.	Cultivar Name	Overall Rating	Yield (t/ha)[y]		Origin	
			total	marketable	company/ institute	country
1	40 Days Early	B+	13.6ab	12.6a	Nong Seng Co.	Taiwan
5	Hsia Hsueh Kan	C	9.4def	8.5cde	Hsing Nong Co.	Taiwan
27	Kan Tsu	C	7.9ef	7.1cdef	Taiwan Seed Service	Taiwan
45	Natsuminowasei No.3	C	10.9bcd	9.0bcde	Takii & Co.	Japan
58	Radish	B	10.2cdef	9.4bcd	Chia Kwang Co.	Thailand
106	Winter Keeper	C+	10.0cdef	8.0cdef	Choong Ang Co.	Korea
107	Summer Top	B+	14.1a	11.9ab	Choong Ang Co.	Korea
109	Muzinzang	C	8.2def	6.0ef	HeungNong Co.	Korea
110	Daeburyong	C+	10.5cde	9.5bcd	HeungNong Co.	Korea
113	Young-Kwang	C	9.0def	5.1f	Seoul Co.	Korea
114	Baeck Kyung	C+	9.8cdef	8.9bcde	Seoul Co.	Korea
115	Keumbangseok	C	9.5cdef	8.3cde	Seoul Co.	Korea
134	Wuan-Hseng Kan	C	7.2f	6.0ef	Taiping Cooperative Farm	Taiwan
135	Pu-Toung Kan	C	7.9ef	6.8def	Taiping Cooperative Farm	Taiwan
165	Ta-Pai	C	12.4abc	10.3abc	Ta Liao Farmer	Taiwan
167	Mei-Hwa	C-	7.4f	6.5def	Ta Liao Farmer	Taiwan
166	Tau-Yuan	C-	8.7def	7.5cdef	Ta Liao Farmer	Taiwan

[z]Date sown: July 13, 1984; date harvested: Aug. 29, 1984 to Sept. 6, 1984. [y]Mean separation within columns by Duncan's multiple range test at 5% probability levle.

Table 20. Performance of selected radish cultivars in various growing seasons from 1982 to 1984 at AVRDC.

Coll. No.	Entry Name	Marketable Root Yield (t/ha)					Mean HT (%)	ESY[x] (t/ha)	Rating
		1982		1983	1984	mean			
		sp[z]	fall[z]	fall[y]	su[y]				
1	40 Days Early	16.0	10.3	29.2	12.6	17.0	63.6	18.6	5
5	Hsia Hsueh Kan	14.3	9.3	20.6	8.5	13.2	56.7	11.7	
19	Kantzu	9.3	11.5	27.6	–	16.1	–	–	
27	Kan Tzu	14.5	15.2	–	7.1	12.3	46.7	7.1	
45	Natsuminowasei No.3 (Yagi)	5.2	9.3	21.8	9.0	11.3	57.7	12.6	
58	Radish	10.8	16.9	21.9	9.4	14.8	48.5	10.6	
106	Winter Keeper	44.0	11.7	30.1	8.0	23.5	68.4	30.1	2
107	Summer Top	55.0	15.0	33.2	11.9	28.8	49.4	27.2	3
109	Muzinzang	80.0	8.6	29.9	6.0	31.1	31.1	24.9	4
110	Daeburyong	56.0	12.6	22.3	9.5	25.1	54.3	30.4	1
112	Summer Radish	56.0	10.4	45.6	–	37.3	–	–	
113	Young-Kwang	64.0	9.8	46.8	5.1	31.4	18.0	11.5	
114	Baeck-Kyung	32.0	9.5	32.1	8.9	20.6	42.8	13.7	
115	Keumbangseok	40.0	9.8	30.2	8.3	22.1	41.5	16.6	
134	Wuan-Hseng Kan	–	12.7	23.0	6.0	13.9	33.5	7.7	
135	Pu-Toung Kan	–	13.7	25.9	6.8	15.5	34.3	8.9	
159	Radish No.3	–	–	57.2	–	57.2	–	–	
160	House King	–	–	47.4	–	47.4	–	–	
161	Radish No.5	–	–	15.3	–	15.3	–	–	
165	Ta-Pai	–	–	–	10.3	10.3	–	–	
166	Tau-Yuan	–	–	–	7.5	7.5	–	–	
167	Mei-Hwa	–	–	–	6.5	6.5	–	–	
Mean		35.5	11.6	31.1	8.3	21.7			
All entry mean		18.0	7.9	31.1	8.3	13.1			

[z]Observational trials, not replicated. [y]Advanced trials, replicated four times. [x]Estimated summer yield.

Table 21. Root and horticultural characteristics of radish cultivars evaluated in advanced yield trial in summer 1984[z].

Coll. No.	Cultivar Name	Plant Weight (g)	Leaf No. (no./plant)	Root Characteristics weight (g)	length (cm)	width (cm)	Harvest Rate (%)
1	40 Days Early	550	21.5	380	22.9	5.6	78.7
5	Hsia Hsueh Kan	630	16.8	430	17.6	6.5	74.0
27	Kan Tsu	420	16.1	270	15.5	4.8	75.7
45	Natsuminowasei No.3	640	22.8	250	20.0	5.2	68.5
58	Radish	420	22.0	330	21.8	4.8	76.8
106	Winter Keeper	650	21.1	310	15.0	5.1	78.9
107	Summer Top	580	23.3	420	19.7	5.8	73.8
109	Muzinzang	490	17.0	280	14.3	5.2	55.5
110	Daeburyong	480	14.2	300	18.0	5.0	79.4
113	Young-Kwang	620	28.3	320	14.5	6.2	38.5
114	Baeck Kyung	410	23.3	270	14.9	4.9	78.6
115	Keumbangseok	580	27.1	330	13.8	5.3	76.0
134	Wuan-Hseng	460	17.3	280	16.2	5.2	57.9
135	Pu-Toung Kan	400	15.1	270	14.1	5.3	66.1
165	Ta-Pai	700	17.3	460	16.7	5.6	73.5
167	Mei-Hwa	340	14.5	210	14.4	4.9	66.2
166	Tau-Yuan	590	14.7	390	15.1	5.3	68.6

[z]Date sown: July 13, 1984, date harvested: Aug. 29 to Sept. 6, 1984, experimental design: RCBD, four replications

Conclusion

The first phase of this project to evaluate adaptability of commercial cultivars of five vegetables under tropical conditions was completed after three years of trials.

Of the five crops tested, cauliflower and hot pepper seemed to have the most potential. Outstanding cauliflower lines included Chia Thai No. 1, F1 451, and Mikado 40 Days. The best hot pepper cultivars were Passion, Hungarian Yellow Wax, Twist Hot, and Hong Shan Ho.

All of the cauliflower cultivars tested were, however, susceptible to soft rot (*Erwina carotovora*) and black rot (*Xanthomonas campestris*). The best lines, however, escaped severe infection because of their early maturity. Viral diseases, southern blight, and bacterial wilt were the major constraints of hot pepper.

The heat resistance of Chinese radish was rated as adequate in several cultivars. However, proper management practices and selection of soil type were important for these cultivars to perform normally under wet environments.

The performance of sweet pepper was somewhat less promising. Most test cultivars seemed to lack heat tolerance, although the American variety Gypsy produced approximately 30 t/ha.

Snap bean and mustard also performed poorly. Almost all mustard lines, especially the heading type, were susceptible to bolting, turnip mosaic virus, and soft rot; whereas the snap beans suffered from heat, flooding, and fungal diseases. In general, the pole-type snap bean performed slightly better than the determinate varieties; and the leafy mustard cultivars outperformed the heading type.

As seeds of most superior cultivars are readily available from commercial companies, the information gathered here can be given to the national programs of our cooperating countries to promote vegetable production. The results of these trials serve as the basis in the selection of AVRDC mandate crops and problem areas for future research. Feedback information to seed companies could also assist them to research on the problems of their cultivars.

In phase II of this project starting from 1985, promising entries will be further evaluated at the Center's bilateral projects, and will be tested in our Production System Program under specific environments and specific cropping systems in cooperating countries.

Nutrition Chemistry

Sprouting Properties of Small-Seeded Soybean

Introduction

Bean sprout is a traditional oriental vegetable and has become popular worldwide. This nutritious vegetable is produced indoor, thus, its production is not limited by environmental conditions. Because bean sprouts can be produced in only a few days all year round without soil nor pesticides, it can be considered one of the cleanest and most dependable vegetables. Low yield, a hard texture, and a beany flavor are often claimed as major constraints for soybean sprout by local producers and consumers. In this study, the sprouting properties and the quality of a small-seeded soybean varieties were evaluated.

Materials and Methods

Soybean seeds of four varieties with various 100-seed weight were used: AGS2 (5.62), AGS154 (11.65), AGS62 (11.11), and AGS210 (19.83). Selected unbroken and clean seeds were washed and soaked in distilled water for 6 hr under room temperature before sprouting. The sprouting process was carried out under an automatic laboratory sprouting can (Fig 1). The tap water inlet was adjusted to eject a 10-to 15-min water spray at 4-hr intervals. Unless otherwise stated, a physical pressure of 5.8 g/cm^2 was continuously applied during sprouting to improve sprout quality.

An approximate analysis of sprouting conditions was carried out according to the Methods of the Association of Official Analytical Chemists: the micro-Kjeldahl for crude protein and color development induced by 2,6-dichlorophenolindophenol sodium for ascorbic acid. Carbohydrate was determined by high performance liquid chromatography (HPLC) with Brand-Bio-Bad HPLC carbohydrate analysis column (300 × 7.8 mm). All chemicals used were pure grade.

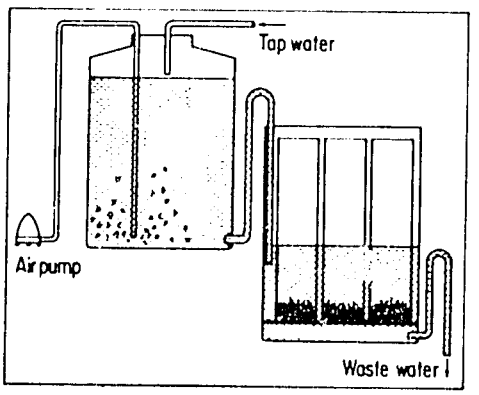


Fig. 1.
Automatic water spray system for bean sprouting.

Results

Sprouting properties. A typical sprouting curve of four soybean varieties are shown in Fig 2. A clear train was observed: the smaller the seed, the higher the sprout yield. A sprout and seed ratio of 8:1 was obtained for AGS2 after five days. The yield was even higher, as the sprouting process was extended. Molds were found on AGS62. These could be a genotypic characteristic or the result of poor seed quality. This variety had a higher soluble nitrogen content than the other three varieties tested and was, therefore, excluded for composition analysis.

Sprout properties of these four varieties are summarized in Table 1. The small-seeded soybean had longer sprouts with a smaller diameter. The cotyledon was softer and the sprout less crispy. Sprout diameter generally reached its plateau after two to three days. Panels found the sprouts from AGS2 acceptable in taste but preferred the short sprouts with bigger diameter.

Effect of chemical treatments on sprouting of soybean. In order to improve sprout quality, 2,4-D and $CaCl_2$ treatments were used. The chemicals were applied three times a day. The results are summarized in Table 2. It showed that 2,4-D treatment inhibited enlongation and enlarged soybean sprouts. As a result, it reduced the yield.

On the other hand, $CaCl_2$ enlarged the sprouts but did not reduce the yield. The addition of calcium also improved the texture and the crispiness of AGS2. The combination of physical pressure and $CaCl_2$ treatment seemed to be a promising approach in the sprouting of small-seeded soybean. The use of physical pressure and $CaCl_2$ in this experiment was

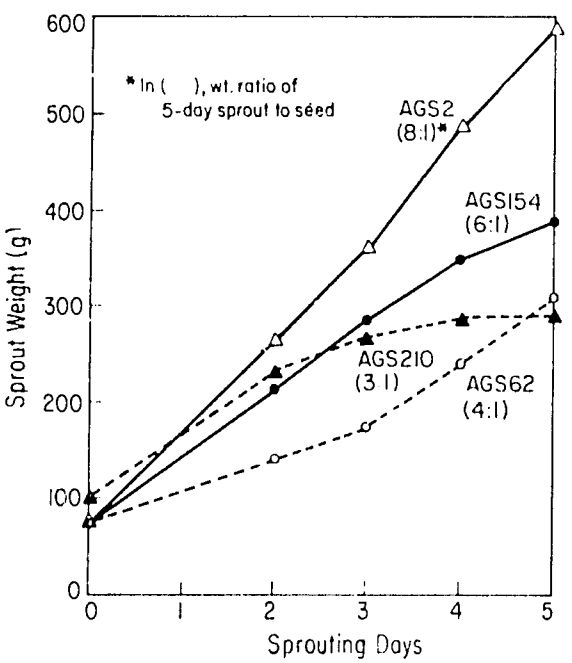


Fig. 2.
Sprout production of four different varieties of soybean.

Table 1. Sprouting properties of four soybean varieties.

Variety	Length (mm)	Diameter (mm)	Cotyledon[z] Hardness	Crispiness[y]
AGS2	177	1.75	+	+
AGS154	155	2.00	+	+
AGS62	50	2.10	+ +	+ +
AGS210	38	2.40	+ + +	+ + +

[z] + hard + + harder, + + + very hard [y] + not crispy, + + crispy, + + + very crispy.

adopted from the mungbean sprout preparation. More detailed experiments are needed to find the optimum condition for soybean sprouts.

Chemical constituents of soybean sprouts. Ascorbic acid is a nutrient which is not present in the legume seed but is abundant in the sprouts. Daily analysis showed that it increased during the sprouting process. The Vitamin A content of soybean sprouts harvested on the 5th day are summarized in Table 3. The addition of 2,4-D reduced the Vitamin C content of soybean sprouts to about 50% of the physical pressure control. On the other hand, $CaCl_2$ enhanced it to more than 20 mg/100 g which is comparable to that of mungbean sprouts.

Unlike mungbean, the soybean seed contains sucrose and oligosaccharides as the major carbohydrates. Both elements are water soluole and oligosaccharides may cause flatulence. A Brand-Bio-Rad HPLC carbohydrate analysis column was used to determine the sugar composition of the small-seeded soybean variety. This column can not successfully separate stachyose and raffinose, but the sum of these two oligosaccharides is expressed as total oligosaccharides (Fig 3).

A sharp decline in sucrose and a rapid increase in fructose were observed during the first two days. A slow decrease in sucrose and fructose followed until the end of the sprouting process. A decrease in oligosaccharides also occurred up to three days, after which the amount could not be measured anymore.

A decline in xylose was also detected, but glucose content remained the same throughout the entire sprouting process. The addition of 2,4-D and $CaCl_2$ did not affect this general pattern. (The data in Fig. 3 refers to sugar (mg) per seed). The effect of moisture content was adjusted. Carbohydrate loss and consumption during the sprouting process may be estimated with the use of the same figure. About 60% of free sugar was converted to other elements or lost during sprouting under our conditions.

Table 2. Effect of chemical treatment on sprouting properties of soybean.

Treatment	Sprout Yield g/g of seed	Length (mm)	Diameter (mm)	Cotyledon[z] Hardness	Crispiness[y]
Physical pressure					
AGS2	8.0	177	1.75	+	+
AGS154	6.0	155	2.00	+	+
AGS210	3.0	58	2.40	+ + +	+ + +
Phy. pressure + 2,4-D					
AGS2	4.0	35	2.20	–	–
AGS154	3.2	34	2.50	–	–
AGS210	3.0	18	2.70	–	–
Phy. pressure + $CaCl_2$					
AGS2	8.0	160	2.30	+ +	+ + +
AGS154	5.0	90	2.40	+ +	+ + +
AGS210	3.0	45	2.50	+ + +	+ + +

[z] + hard, + + harder; + + + very hard; – too soft. [y] + not crispy; + + crispy; + + + very crispy; – too soft.

Table 3. Vitamin C content of soybean sprout.

Variety	Vitamin C Content (mg/100 g)		
	phy. pressure	phy. press. + 2,4-D ($5x10^{-5}$M)	phy. press. + $CaCl_2$ ($1x10^{-2}$M)
AGS2	17.2	10.0	25
AGS154	16.1	11.0	20
AGS210	15.5	6.1	18

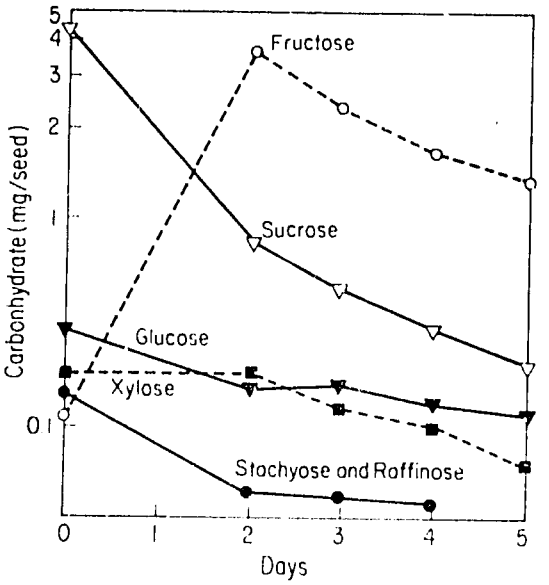


Fig. 3.
Carbohydrate distribution during sprouting (AGS2).

Conclusion

Preliminary results showed that small-seeded soybean gave higher sprout yield and softer cotyledon texture. The addition of $CaCl_2$ improved its texture and Vitamin C content and had no effect on yield. However, the sprouts were still too long; and so, further improvement will be needed in the future.

Effect of Sweet Potato Starch on Digestibility and Feeding Efficiency of Dietary Protein

Introduction

Previous work demonstrated that low digestibility of sweet potato dietary protein is due to its starch properties. Isolated sweet potato starch reduces the digestibility of casein, but this effect can be partially overcome by precooking the starch. Further investigations showed that starch isolated from different varieties had different inhibiting effects. Few lines, such as CN1232-9 and C63-74, were identified as containing easily digestible starch. This work was conducted to confirm previous results on sweet potato roots produced in 1984.

Materials and Methods

To prepare the starch, sweet potato roots were washed, milled, and filtrated through a 132-mesh bolting cloth. The filtrate was sedimented and then air-dried to get the starch fraction.

Long-Evans rats of 10 and 4 weeks old were used to determine biological value (BV) and protein efficiency ratio (PER), respectively. Four rats were used for each treatment. Ten percent of casein was used as protein source for all the experiments studied. Protein content of sweet potato was adjusted by adding an equal amount of starch isolated from the same variety before formulating the diet. Starch content of experimental diet was 60% for both BV and PER studies.

Results

The effect of isolated sweet potato starch on casein digestibility and biological value are summarized in Table 4. Four sweet potato lines were included in this experiment and corn starch was used as control. These results confirmed our previous study that starches isolated from C63-74 and CN1232-9 were easily digestible. Those of two local check cultivars, New 31 and TN18, were less digestible, but there was no difference between TN18 and the two improved lines. Although the difference in digestibility between corn and these two new cultivars was statistically significant, we still believed that the latter were less digestible than corn. Since casein was the common protein source for all the treatments, we found no difference on biological value with one exception (New 31).

Whole sweet potato dry powder was used to study the protein efficiency ratio and feeding efficiency of selected sweet potato lines. Based on 1983 results, C63-74 and CN1232-89 represented the highly digestible lines, and CN1219-1 and 941-32, the low digestibility lines. A precooked sample of CN1232-9 was also included for comparison. The PER value of those lines are summarized in Table 5. No statistical difference was observed on PER among all the treatments during the first two weeks. The difference was observed on the third and fourth weeks. Corn starch still came out better than the starches of all the sweet potato varieties tested. However, the PER value of AVRDC new breeding line CN1232-9 showed no significant differences from that of the corn starch control after four weeks. Precooking of CN1232-9 did not affect its PER value.

The feeding efficiency of sweet potato lines was also recorded (Table 6). At the fourth week, the corn starch diet was significantly better than all the sweet potato diet tested. CN1232-9 was again identified as the best line. The low feeding efficiency of sweet potato diets could be due to the low metabolic energy content of this commodity as adjusted through feed formulation. The contribution of sweet potato to dietary protein will be limited due to its low protein content. The composition of these amino acids for four sweet potato lines are listed in Table 7.

Soybean meal and yellow corn are generally the major protein source of animal feed and the suggested daily allowance for pigs are crude protein, 14%; lysine, 0.6%; isoleucine, 0.4%; methionine, 0.3%; tryptophan, 0.11%; threonine, 0.37%. A calculation was made based

Table 4. Digestibility and biological value of the sweet potato starch diet[z].

Starch Source	Carbohydrate Digestibility	Fecal Nitrogen	Apparent Digestibility	True Digestibility	Biological Value
C63-74	99.67 a	1.83 b	83.02 a	88.46 a	85.05 ab
CN1232-9	99.69 a	1.80 b	82.37 a	88.58 a	87.28 a
New 31	98.20 b	2.68 a	73.57 b	82.51 b	79.79 b
TN18	99.51 a	1.93 b	79.70 ab	85.78 ab	83.60 ab
Corn	99.74 a	1.52 b	85.78 a	91.39 a	89.22 a

[z]Casein as protein source for all the treatments. Mean separations within columns by Duncan's Multiple Range Test (DMRT) at the 5% level.

Table 5. Protein efficiency ratio of sweet potato diet.[z]

	Experimental Period (wk)			
	1st	2nd	3rd	4th
C63-74	2.37 a	2.10 a	2.32 ab	2.29 bc
CN1232-9 (raw)	2.05 a	2.20 a	2.39 ab	2.46 ab
CN1232-9 (cooked)	2.28 a	2.02 a	2.18 bc	2.27 bc
CN1219-1	2.16 a	1.77 a	1.88 c	2.05 c
941-32	2.03 a	2.04 a	2.22 abc	2.11 c
Corn	2.77 a	1.97 a	2.64 a	2.60 a

[z]Mean separation within columns by Duncan's Multiple Test (DMRT) at the 5% level.

on the assumption that 25% of yellow corn was to be replaced by sweet potato. Methionine is the limiting amino acid for all the four sweet potato lines. Since there is not much difference among them, no modification is required when shifting from traditional cultivars (ca. New 31 and TN18) to improved cultivars (ca. C63-74 and CN1232-9) for amino acid supplementation.

Conclusion

This study demonstrated that CN1232-9 is easily digestible and has good starch quality. It can be directly used as feed without cooking. It also has good agronomic characteristics (high yield, high dry matter, and wide adaptability).

Table 6 Feeding efficiency of sweet potato diet.[z]

	Experimental Period (wk)			
	1st	2nd	3rd	4th
	body wt in grams/100 g feed			
C63-74	24.80 ab	22.00 a	24.35 ab	24.08 bc
CN1232-9 (raw)	20.30 b	21.80 a	23.70 bc	24.45 b
CN1232-9 (cooked)	24.80 ab	22.03 a	23.70 bc	24.70 b
CN1219-1	22.43 ab	18.30 a	19.50 c	21.40 d
941-32	20.95 b	20.98 a	22.75 bc	21.83 cd
Corn	25.85 a	21.25 a	28.43 a	28.00 a

[z]Mean separation within column by Duncan's Multiple Range Test (DMRT) at the 5% level.

Table 7. Composition of selected amino acids of four sweet potato lines.

Cultivars	Amino Acids (mg/16 g N)[z]				
	Lys.[y]	Ile.[y]	Met.[x]	Trp.[w]	Thr.[y]
C63-74	130	76	23	6.8	53
CN1232-9	92	68	27	6.0	38
New 31	73	63	28	5.2	28
TN18	94	67	20	5.6	46

[z]Lys. = lysine, Ile. = isoleucine, Met = methionine, Trp. = tryptophan; Thr. = threonine. [y]Analyzed by the amino acid analyzer. [x]Analyzed by the microbiological assay. [w]Analyzed by alkaline hydrolysis.

Near Infrared Reflectance Spectroscopy for Compositional Analysis of Soybean, Mungbean, and Sweet Potato

Introduction

Near infrared reflectance spectroscopy (NIRS) determines compositions through the measurement of diffuse reflectance of near infrared light. It can analyze several compositions simultaneously through proper selection of different filter combinations and provide a rapid, low-cost, analytical tool which does not generate waste fumes. This machine has received widespread interest and has been successfully used for analyzing the compositions of corn, soybean, wheat, milk powder, tea, etc.

This study aimed to measure the reliability of NIRS in predicting compositions of soybean, mungbean, and sweet potato to replace or supplement the presently adopted routine analytical procedures in our laboratory.

Materials and Methods

Soybean, mungbean, and sweet potato samples were obtained from AVRDC breeders. Soybean and mungbean seeds were ground with a rotor-speed mill and udy cyclone sample mill, respectively. Sweet potato chips were dried at 45°C for 72 hr before grinding.

Wet chemical analytical methods for various constituents are as follow: moisture oven-dry method (105°C); crude protein-micro-Kjeldahl method (Nx6.25); crude fat-soxhlet extraction method under n-hexane; sugar-anthrone method; starch-perchloric acid hydrolysis method; crude fiber-acid and alkaline hydrolysis method.

The Technicon Infraalyzer 400 connected to the HP 85 personal computer for data recording, and the multiple linear regression program provided by the instrument company were used for statistical analysis, filter selection, and calibration. The statistical parameters used were the correlation coefficient, standard error of prediction, and skew of the prediction curve. Those factors were adopted for the filter selection procedure of this study.

Results

The NIRS technique is a major breakthrough in routine commodity analysis. There are many factors which influence the performance of NIRS: its physical design, the statistics package, laboratory analysis, and the selection and presentation of samples. The statistic package provided by the instrument company is basically a stepwise regression program by which the best set of filter combination is selected for prediction.

An accurate, precise, and standard laboratory analysis is essential for the successful application of NIRS, against which the equipment is to be calibrated. It is generally accepted that the coefficient of variance (CV) for laboratory analysis should not exceed 2.5%. Since each standard laboratory analysis method has certain assumptions, the CV of standard laboratory analysis varies according to the nature of constituent and commodity. The CV of laboratory and NIRS analysis are listed in Table 8 for comparison. The CV of most constituents analyzed by laboratory methods were less than 2.5%, except those of sugar and crude fiber of sweet potato. The CV observed with NIRS were less than that of the conventional method for all the constituents tested, except for soybean fat. These results suggest the NIRS analysis carried out in our laboratory is acceptable for routine analysis.

There are no standard method to determine the number of filters required for a most reliable prediction of a given constituent. At least two sets of samples are required for calibration and filter selection. Three to six filters gave a more reliable prediction for most constituents tested.

Conditions and statistical information for all the constituents tested are summarized in Table 9. The correlation coefficient (R^2) of the calibration curve varied from 0.92 to 0.99. Constituents with relatively lower R^2 were mungbean starch, and sweet potato sugar, and starch. This lower value was partially due to the higher CV of the conventional method and its operational definition. The accuracy of NIRS was expressed by the standard error of prediction (SEP) which varied from 0.10 to 0.68 under our experimental conditions. However, accuracy is a subjective matter depending on the purpose of the analysis. Since most of our

Table 8. Coefficient of variance of replicated analysis.

Commodity	Constituent	Coefficient of Variance (%)	
		conventional method	NIRS method
Sweet potato	moisture	1.226	1.042
	protein	1.343	1.310
	sugar	3.404	2.077
	starch	2.051	0.963
	crude fiber	4.292	2.760
Soybean	moisture	0.775	0.457
	fat	0.552	0.830
	protein	0.864	0.576
Mungbean	moisture	1.585	1.145
	protein	1.039	0.999
	starch	2.086	1.095

analysis were for varietal evaluation, and the standard error of the field experiment was larger than SEP, both precision and accuracy for NIRS were acceptable for our purpose.

NIRS, as Technicon 400, is a semiempirical technique which requires calibration with a set of data by a primary laboratory method for each particular compound. Unknown samples were quantified through a calibrated prediction equation. This approach, however, did not guarantee an accurate prediction for new unknown samples of different varieties or cultural practices. Table 10 summarizes the data of two sets of prediction samples. A twofold difference on SEP can be observed between these two prediction samples. Meantime, the skew value changed from less than 1 to more than 1. Changing filter combinations did not reduce the difference.

Table 9. Characteristics of selected calibration curves for soybean, mungbean, and sweet potato.

Commodity	Component	Best Combination of Filter	R^2 of Calibration Curve	Content Range of Calibration	Sample Size	SEP of Calibration Test	No. of Sample for Calibration Test
Soybean	moisture	3,4,6,10,16	0.99	6.73 – 13.1	78	0.11	20
Soybean	protein	8,9,11,12,17	0.98	32.87 – 43.22	100	0.28	26
Soybean	oil	6,13, 15	0.97	14.97 – 21.67	39	0.21	23
Mungbean	moisture	11,12,14,17,19	0.99	6.97 – 12.47	129	0.10	16
Mungbean	protein	4,9,10,12,20	0.99	19.64 – 27.61	136	0.18	16
Mungbean	starch	2,4,13,14,15	0.92	35.59 – 44.36	61	0.48	25
Sweet potato	moisture	5,10,16,17,20	0.97	3.48 – 9.71	50	0.13	24
Sweet potato	protein	3,6,7,12,14	0.98	1.47 – 11.07	70	0.24	33
Sweet potato	sugar	10,13,14,15,20	0.93	7.66 – 19.79	101	0.33	25
Sweet potato	starch	4,5,6,10,13,16	0.97	44.33 – 73.78	86	0.68	20
Sweet potato	fiber	6,7,8,10,11,16,19	0.93	1.31 – 4.69	62	0.22	28

Table 10. Influence of filter numbers and combination on the accuracy of NIRS for the determination of soybean oil content.

Filter No.	Filter Combination	Calibration Test I			Calibration Test II		
		SEP[z]	R	skew	SEP[z]	R	skew
3	6,13,18	0.213	0.983	0.943	0.410	0.981	1.034
3	6,13,15	0.211	0.984	0.970	0.411	0.981	1.040
3	8,13,18	0.225	0.981	0.954	0.406	0.981	1.038
4	8,12,18,20	0.242	0.977	0.947	0.489	0.973	1.041
4	8,13,15,20	0.218	0.984	0.937	0.436	0.979	1.033
4	10,12,18,20	0.226	0.980	0.955	0.477	0.974	1.037
5	8,10,13,15,20	0.381	0.952	0.836	0.491	0.973	1.050
5	12,14,15,16,19	0.288	0.972	0.929	0.421	0.982	1.045
5	8,10,13,18,20	0.236	0.980	0.896	0.470	0.975	1.043

[z]Standard error of prediction.

Conclusion

Results suggest that checking each batch of sample with conventional method is still probably needed to ensure that the accuracy of NIRS prediction is within the acceptable range. Improvement on this regard is needed if NIRS is to be widely accepted for broader application.

Preliminary Studies on Optimum Beancurd-Skin Processing Conditions

Introduction

Traditional soybean foods can be classified into two groups: fermented and nonfermented. Beancurd skin ("tofie") is a nonfermented soybean food. It is formed on the surface of

soybean milk during gentle heating. Usually, it is dried at room temperature and stored for several months. It is without any strong flavor and is rich in protein (around 50%) and fat (25%). It is often produced by hand in small factories, although there is mass-production technology available. The potential of this nutritious product for developing countries has been overlooked.

Yield and quality of beancurd skin are affected by temperature, pH, ingredients, and soybean quality. Optimum conditions for its production are studied in this report.

Methods and Materials

Seeds of AGS 210, 154, 62, and 2 harvested in 1983 were used for variety comparison; and AGS129 harvested in 1983, 1982, and 1981 were selected to study the storage effect.

The flow diagram of beancurd-skin production is shown in Fig. 4. Three different bean-water ratio-1:6, 1:8, and 1:10-were used to determine topie yield and quality evaluation. Processing carried out in a flat aluminum pan and hot plates was used for temperature control. Unless otherwise stated, beancurd-skin formation was under the following conditions: bean-water ratio = 1:8, temperature = 85°C, milk depth = 1.5 cm. Protein and fat were analyzed according to the AOAC method. Color and flavor were evaluated by a laboratory panel subjectively.

Results

Boiling 40% of the desired water and adding it to the ground beancurd skin resulted in better yield and higher protein and oil recovery. The results of the different bean-water ratio on beancurd skin yield and quality are summarized in Table 11. Higher bean-water ratio increased protein and fat recovery and thus, of yield per unit weight of seed. However,

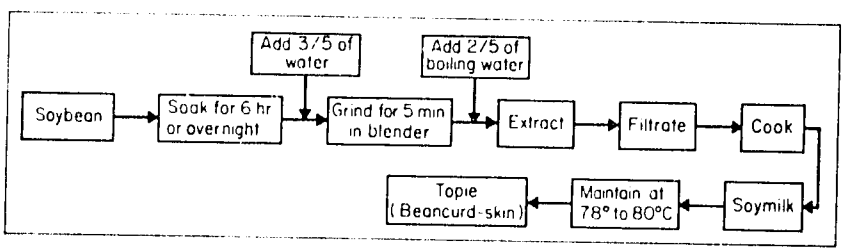


Fig. 4. Flow chart of topie production.

Table 11. Effect of bean-water ratio on yield and quality of beancurd skin (topie).

	Bean-Water Ratio		
	1:6	1:8	1:10
Topie yield (g/100 ml SM)[z]	4.8	4.1	3.2
(g/100 g SB)[y]	31.9	37.5	37.4
Protein recovery (%)	46.1	53.8	52.8
Oil recovery (%)	44.3	50.0	49.8
Efficiency (gr topie/min)	0.54	0.48	0.39
Specific weight (g/cm^2)	0.12	0.12	0.10
Color[x]	+	+ +	+ + +
Beany flavor[w]	+	+	+ +
Protein content (%)	53.7	53.3	52.5
Fat content (%)	25.2	24.2	24.2
Moisture content (%)	4.6	5.0	4.4

[z]SM = soy milk. [y]SB = soybean. [x]Color: + = pale yellow; + + = light brown; + + + = dark brown.
[w]Flavor: + = minimal, + + = severe;

production efficiency expressed in grams of beancurd skin produced per unit of time, was better with the lowest bean-water ratio. The topie also had a lighter color.

The results of the two temperatures (75°C and 90°C) tested for topie formation are summarized in Table 12. In general, the recommended topie formation temperature is just below the boiling point. Although this temperature (90°C) did not influence yield and protein recovery, it improved efficiency and quality. Four depths of soybean milk in the flat pan during topie formation were compared and the results are summarized in Table 13. A higher yield and protein recovery resulted with the depth of 2.5 to 3 cm. However, it reduced quality; the beancurd skin had a darker color and stronger beany flavor.

The effect of soybean variety on topie production is shown in Table 14. Of the four soybean varieties (AGS210, AGS62, AGS154, and AGS2) used, AGS62 produced an unacceptable topie with very poor texture. The soybean with larger seed size tended to have higher topie yield and better protein and fat recovery.

AGS129 harvested at different years and stored at room temperature was used to study the duration of soybean quality for topie formation. The results are summarized in Table 15. Beancurd skin prepared from beans stored for three years had a very bad odor and poor quality. It also had lower yield and poor protein and fat recovery. Yield and quality from the 1982 and 1983 harvests were comparable. Since the soybean used were harvested from different trials, it was not determined whether the poor topie yield and quality of the 1983 soybean was entirely due to the effect of storage.

Conclusion

Information in this nonreplicated preliminary experiment is certainly not enough to recommend appropriate topie-making conditions. The strength of topie film, the effect of

Table 12. Effect of temperature on topie formation.

	75°C	90°C
Topie yield (g/100 ml SM)[z]	4.84	4.83
(g/100 g SB)[y]	44.4	44.5
Protein recovery (%)	63.3	63.8
Efficiency (g/min)	0.45	0.48
Specific weight (g/cm^2)	0.122	0.122
Color[x]	+ +	+
Beany flavor[w]	+ +	+
Protein content (%)	53.0	53.3
Oil content (%)	24.2	25.1
Moisture content (%)	4.0	5.0

[z]SM = soy milk. [y]SB = soybean. [x]Color: + = pale yellow; + + = light brown. [w]Flavor. + = minimal; + + = severe.

Table 13. Effect of different depths of soy milk on topie formation.

	1.0 cm	1.5 cm	2.0 cm	2.5-3.0 cm
Topie yield (g/100 ml SM)[z]	4.49	4.56	4.69	5.52
(g/100 g SB)[y]	36.82	38.30	38.46	46.36
Protein recovery (%)	50.09	54.53	55.67	67.35
Efficiency (g/min)	0.48	0.56	0.54	0.58
Specific weight (g/cm^2)	0.12[illegible]	0.134	0.118	0.137
Color[x]	+	+	+ +	+ +
Beany flavor[w]	+	+	+	+ +
Protein content	50.5	52.9	53.8	54.0
Oil content	25.1	25.3	25.5	25.9
Moisture content	5.8	5.3	3.5	5.9

[z]SM = soy milk. [y]SB = soybean. [x]Color: + = pale yellow; + + = light brown. [w]Flavor: + = minimal; + + = severe.

chemical ingredients, and the storage properties of topie formed under various conditions all deserve further investigations. From this study, however, it can be determined that carefully selected seeds which have not undergone long storage, processed under a bean-water ratio of 1:8, and gently heated at 90°C in a milk depth of 2.0 to 2.5 cm may provide the basic requisites for beancurd-skin processing.

Table 14. Effect of soybean variety on topie formation

	AGS210	AGS62	AGS154	AGS2
Seed size g/100 seed	21.8	14.5	13.4	9.2
Seed protein content (%)	34.4	39.9	35.7	41.8
Seed fat content (%)	19.7	17.6	16.7	14.0
Topie yield g/100 ml SM	4.87	3.92	4.43	3.67
Topie yield g/100 g	seed	34.1	27.4	27.9
Protein recovery (%)	50.7	36.0	48.9	37.4
Oil recovery (%)	48.8	34.0	55.8	40.6
Efficiency (g/min)	0.53	0.42	0.48	0.45
Specific weight (g/cm^2)	0.15	0.15	0.15	0.12
Color[z]	+	+ + +	+	+ +
Beany flavor[y]	+ +	+	+ + +	+
Topie protein content (%)	51.1	52.3	51.9	56.1
Topie oil content (%)	28.3	21.8	27.7	20.4

[z]Color: + = pale yellow, + + = light brown, + + + = dark brown. [y]Flavor: + = minimal, + + = severe, + + + = very strong.

Table 15. Effect of storage duration on topie formation.

	Storage Duration (year)		
	3	2	1
Moisture content of soybean (%)	7.67	7.70	7.74
Protein content of soybean (%)	39.0	37.9	37.2
Oil content of soybean (%)	22.7	19.5	18.1
Topie yield (g/100 ml soybean milk)	4.39	5.27	6.70
Topie yield (g/100 g seed)	33.4	40.1	40.2
Protein recovery (%)	44.2	55.4	54.6
Oil recovery (%)	41.3	53.5	55.3
Efficiency (g/min)	0.49	0.57	0.58
Specific weight (g/cm^2)	0.14	0.14	0.12
Color[z]	+	+ +	+
Beany flavor[y]	x	+ +	+
Protein content of topie (%)	51.7	52.4	50.5
Oil content of topie (%)	28.1	26.0	24.9

[z]Color: + = pale yellow, + + = light brown. [y]Flavor: + = minimal, + + = severe, x = bad odor not acceptable.

Flatulence Induced by Sweet Potato

Introduction

Last year's study demonstrated that sweet potato can induce hydrogen production in experimental rats. Starch is probably the major flatulence-inducing substance of sweet potato. This effect, however, can be partially reduced by cooking sweet potato. It was also noticed that certain sweet potato lines induced more flatus than others. These results suggested that the flatulence-inducing substances in sweet potato are different from those of legumes which are mainly oligosaccharides. To confirm these findings, this detailed study on carbohydrate composition has been initiated both at AVRDC and the VPI State University on the possible role of nonstarch polysaccharides in inducing flatulence.

Methods and Materials

Samples were taken within 24 hr after harvest. The system used for flatulence evaluation was the same as in last year. Selected Long-Evans rats (eight weeks old) were not fed for 24 hr prior to each test day. Each rat was placed in a life-supporting metabolic chamber with 12 g of testing diet. Hydrogen content of the respiratory air was measured by a gas chromatograph 16 hours after feeding. Sweet potato starch or starch of other commodities used in flatulence evaluation were all isolated in the laboratory, washed with water, and filtered through three layers of bolting cloth (132 mesh).

The enzymatic hydrolysis procedure for carbohydrate composition analysis was adopted from Dr. J. K. Palmer*. Basically, this method separates carbohydrates into three groups: free sugar, starch, and nonstarch polysaccharides (NSP). Carbohydrates solubilized in 85% ethanol is defined as free sugar. Starch is estimated by hydrolysis with glucoamylase. Protein was removed by adding protase, and the residual was considered as NSP. NSP can be further classified as pectic substances, hemicellulose, and cellulose base on monomer composition and hydrolysis condition.

Results

The findings that sweet potato starch induces flatulence led us to investigate whether other starches have a similar property. Hydrogen production induced by selected starch sources are summarized in Table 16. Regardless of the high standard deviation of the assay method, these starches can still be classified into two groups: low-flatus (corn, rice, mungbean, cassava, and wheat starches) and high-flatus; and (sweet potato, potato, and banana starches). Results showed that other starches, outside of sweet potato, can induce flatulence in experimental animals. This property, however, remains to be investigated further.

Fig. 5 shows that cooking markedly reduced the flatulence-inducing property of selected starches. Cooking for 15 to 25 minutes in 85°C was sufficient to reduce flatulence in high-flatus starch to the level of less than 20 ml/1 g of starch. Cooking, on the other hand, did not affect this property on low-flatus starch. These results suggested that flatulence might operate through different mechanisms. Table 17 lists the hydrogen production of starch isolated from different sweet potato lines. Few lines have been tested in 1983 which were listed for comparison.

One major constraint to conducting flatulence-stimulation work is the great variation among replications as shown by the high standard deviations. One improvement tried this year was to select experimental rats on the corn starch diet, and only those which did not produce hydrogen were used. In addition, the number of rats were increased from 4 to 6 for each determination. Thus, the coefficient of variance was reduced from 50% down to 30% and variant differences detected statistically.

Table 16. Hydrogen production induced by various starch.

Starch Source	Hydrogen Production[z] (ml/g intake)
Sweet potato	69.71 a
Banana	59.46 a
Potato	56.84 a
Wheat	15.89 b
Cassava	9.93 b
Mungbean	5.58 b
Rice	5.04 b
Corn	1.36 b

[z]Mean of eight rats, mean separation within columns by Duncan's Multiple Range Test (DMRT) at the 5% level.

* Dr. J. K. Palmer of the Virginia Polytechnic Institute and State University.

Although experimental results showed that starch was the major flatulence-inducing substance of sweet potato, it did not exclude the possibility of other carbohydrate sources, especially cooked sweet potato. Lines high and low in flatulence, as well as dry and wet in texture, were included in the carbohydrate composition analysis. Table 18 summarizes the

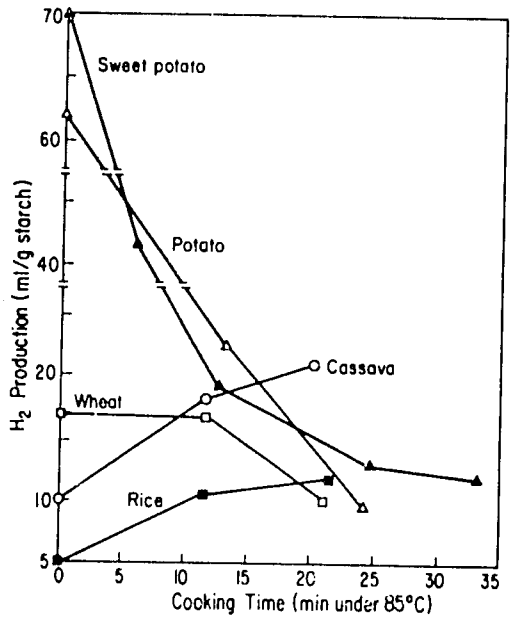


Fig. 5.
Effect of cooking on respiratory hydrogen production induced by starch.

Table 17. Hydrogen production induced by sweet potato starch.

Cultivar	Hydrogen Production (H_2 ml/1 g intake)	
	1984	1983
New 31	90.0	–
CN1229-14	75.8	86.3 ± 41.9
CN1229-2	70.1	59.0 ± 48.5
CN1108-13	45.8	–
CN1219-1	45.7	44.3 ± 40.9
CN1232-9	41.1	74.1 ± 18.7
TN57	22.0	55.2 ± 48.6
LSD (0.05) =	31.2	

Table 18. Carbohydrates of selected sweet potato cultivars.

Cultivar	Moisture Content[z]	Starch	Free sugar	NSP	Flatulence (H_2 ml/g intake)
	----------% dry weight----------				
367	86.5	31.9	38.3	18.9	12.3
CN1121-312	84.9	42.3	26.0	20.6	10.2
CN942-47	80.5	43.8	28.0	13.7	15.1
CN1229-16	69.7	70.4	12.9	8.0	10.9
CN1425-3	79.1	59.1	12.7	14.3	14.9
C63-74	67.4	67.2	9.1	11.9	10.9
CN1219-1	77.1	63.8	12.2	13.5	23.7
CN1232-9	82.0	63.3	13.0	15.6	26.2
LSD (5%) =					15.12

[z]Fresh weight basis.

major carbohydrate compositions of selected sweet potato lines. The first three lines are typically wet cultivars which contain high free sugar and low starch. CN1229-16, CN1425-3, and C63-74 are dry cultivars with high starch and low free sugar contents.

However, texture characteristics of fresh samples were not very reliable because the saccharification process during cooking was not included for consideration. CN1219-1 and CN1232-9 are high-flatulence cultivars, but starch content (or free sugar content) was not necessarily related to hydrogen induction. A more detailed characterization of its starch property is needed for a better understanding of this phenomenon. The NSP composition of these lines are under investigation at both the VPI State University and AVRDC.

Conclusion

Investigation on flatulence inducing properties of selected starch sources revealed that sweet potato, potato, and banana induced higher hydrogen production of experimental rats than other starches. Carbohydrate composition analysis was applied to high-and low-flatulence sweet potato lines. No definite relationship was observed between flatulence-inducing property and carbohydrate composition. Part of the difficulty is the high CV of the testing method.

·362

Soil Microbiology

Developing a Garden Compost Bed

Introduction

The addition of organic matter to the soil has long been recognized as an essential component of any cropping system in order to maintain good soil tilth, release plant nutrients over the growing season, maximize yield, and retain moisture, among others. A modified sheet composting method was designed to eliminate the intensive labor requirement associated with traditional composting methods. The compost/growing beds are constructed once and then maintained with the addition of household organic waste materials. This project is aimed to determine the feasibility, cost, water requirements, and area of application of this type of sheet composting system in relation to the Home Garden Project.

Materials and Methods

The sheet compost/planting bed was designed with a specific carbon-to-nitrogen ratio (C:N) for each layer (Fig. 1). The C:N ratio was formulated at 38:1, 14:1, and 68:1 for the bottom, middle, and top layers, respectively.

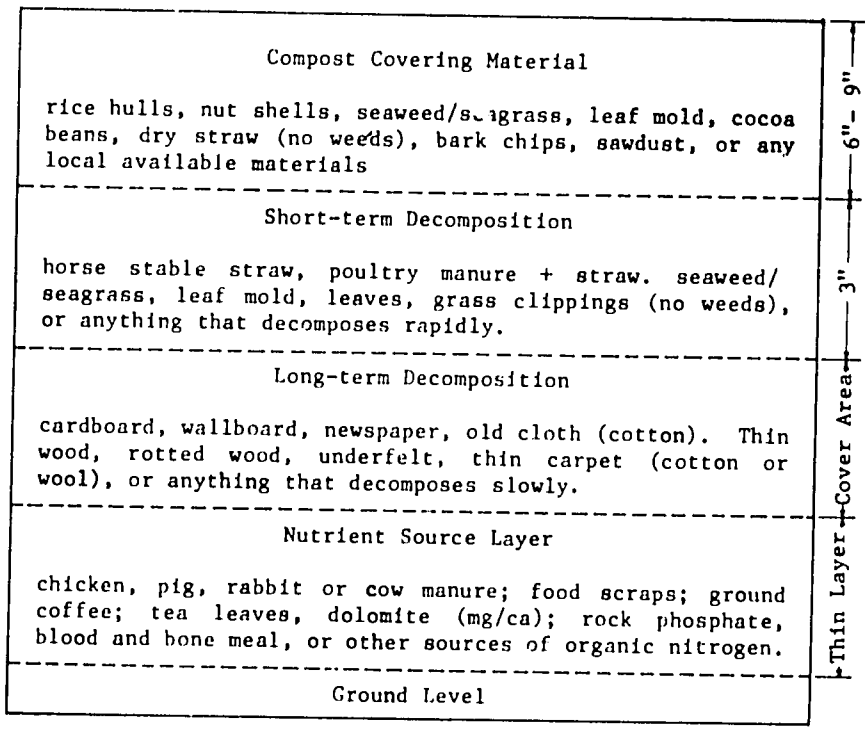


Fig. 1. General model for constructing the layers of a permanent sheet composting/growing bed.

Plant refuse was gathered from various disposal sites around the AVRDC facility. Chicken manure and rice hulls were purchased locally. Peanut hulls were acquired from local farmers. A listing of the gathered materials, amounts used, analysis of each material, carbon-to-nitrogen ratio by layer, as well as a cost estimate are shown in Table 1.

Four 1.2 × 2 m plots were marked off, hand-tilled, and worked into raised beds. Normal fertility practices used by the garden project were applied to two diagonal plots (approximately 5.5 kg of bagasse/plot), while the compost piles were layered, as indicated in Table 1, and watered. An analysis of the soil and bagasse amendment is shown in Table 2. Tomato plants were planted at the ends of each plot followed by Chinese cabbage.

Results

One of the main advantages of this type of planting bed is the fact that the nutrient status of the soil is not a critical factor. This type of bed also allows wide root penetration and proliferation, thus, resulting in optimal nutrient feeding.

Table 1. Analysis of raw materials, C:N ratio by layer, and cost estimate of a permanent compost / planting bed plot.[z]

Material	Dry Wt (kg)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	O.M. (%)	C:N Ratio
Bottom Layer						
Rock phosphate	0.60	0.01	0.001	0.002	0.30	7250.00
Palm leaves	3.06	0.79	0.27	[illegible]29	75.00	73.70
Chicken manure	6.84	2.69	7.18	2.22	35.71	21.56
Paper	0.04	0.04	0.01	0.02	82.79	1567.57
Cardboard	0.27	0.27	0.01	0.21	80.40	214.02
Straw	1.65	0.57	0.31	1.89	64.20	101.58
Sub total	13.07			Layer C:N ratio		18.43
Middle Layer						
Straw	1.51	0.57	0.31	1.89	64.20	101.58
Dry leaves	1.80	1.40	0.25	0.42	57.90	41.46
Chicken manure	9.00	2.69	7.18	2.22	35.71	21.56
Mushroom compost	12.85	0.67	0.40	0.53	16.50	86.05
Peanut hulls	2.90	0.87	0.13	0.42	54.60	66.97
Sub total	28.06			Layer C:N ratio		13.37
Top layer						
Peanut hulls	2.90	0.87	0.13	0.42	54.60	66.97
Soybean trash	1.80	0.82	0.25	0.93	64.20	71.17
Rice hulls	6.75	0.40	0.11	0.23	59.10	143.56
Sub total	11.45			Layer C:N ratio		58.56
Total	52.58					

Cost per 1.2 m by 2 m plot = NT$90.00 (US$2.25).

[z]C:N = carbon-to-nitrogen ratio.

Table 2. Analysis of the soil and bagasse amendment.

	pH	Ash(%)	O.M.(%)	N(%)	P(%)	K(%)
Soil	7.54	96.65	1.36	0.71	0.01	0.01
Bagasse	7.58	69.48	20.70	1.26	1.38	0.65

The compost/planting beds provided all the nutrients required for vigorous growth of both the tomato and Chinese cabbage plants. The check plots showed nutrient deficiencies in tomato with less than optimal growth. There was also more insect damage on tomato fruits in these plots than in those in the compost/planting bed plots. Presently, we have stopped watering all plots and will compare the water-holding capacity of the composting beds and the check plots.

Conclusion

The composting/planting bed concept reduces labor input and water requirements and can be planted with high density crops throughout the year. It has tremendous potential in the Home Garden Program. The evaluation of this type of growing bed is in the early stages and overall conclusions cannot be made at this time.

Problems will be met in the availability of enough organic material to build the initial growing beds and in providing enough water initially for a good breakdown of organic material to humus form. Another potential problem area is in the analysis of raw materials. There is little information in literature and reference manuals regarding the nutrient analysis of organic materials that can be used in any type of composting. Consequently, analysis of raw materials within a particular country would have to be done in order to determine meaningful carbon-to-nitrogen ratios.

Producing Small Quantities of Legume Inoculant Cheaply

Introduction

Legume inoculants in least developed countries (LDCs) are usually imported from Australia or the United States at two to three times their normal selling price. Some LDCs have initiated small pilot inoculant-production plants, but in most cases output and quality control are inadequate, and storage facilities and distribution systems poor. If small quantities could be produced in legume-growing regions and distributed for immediate use , many of the above-mentioned problems would be solved.

Methods and Materials

Empty laboratory bottles for acids (2 1/2 liters) were collected and cleaned. Two liters of liquid mannitol, yeast extract media were distributed in each of six bottles and sterilized.

An actively growing culture of *Rhizobium japonicum* (5 ml) was inoculated in all six bottles. Two of the bottles were placed on the rotary shaker at 120 rpm (standard), two were manually shaken three times per day, and the last two remained stationary. The number of *Rhizobium* cells were determined by the plate count method one, three, five, seven, and nine days after the start of the experiment.

Results

The first experiment became contaminated, but it was obvious from the results that shaking the solution three times per day did not provide adequate oxygen for the rapid growth of *Rhizobium* cells. The experiment was repeated with nine shakings per day, but as can be seen in Fig. 2, it still did not provide adequate oxygen for maximum growth. The experiment was repeated twice more with an oxygen probe to determine the ideal oxygen potential. In both cases the experiment became contaminated due to our inability to sterilize the probe adequately.

A standard air pump used to aerate fish tanks was purchased. Holes were drilled in a rubber stopper for a glass tubing through which incoming air could bubble in the media,

as well as exit from the bottle. A glass tube stuffed with cotton was placed between the air pump and the glass jars and on the exhaust tube to prevent contamination. The experiment was run again and the results are presented in the second graph of Fig. 2.

Rhizobium growth was much better in the rotary-shaken bottles than in the hand-shaken ones. The maximum number of cells was quite good, but it occurred two days after the control standard. Part of the problem was the restriction of the cotton filter between the pump and the glass bottle. Further experiments are planned to reduce the restriction and increase the volume of air bubbling through the liquid media.

Conclusion

This method is viable for small batches of inoculant. There usually is a good supply of empty 2 1/2 liter glass bottles in any type of laboratory facility. The cost of the air pump was NT$120 or approximately US$3.00. We will continue to refine this method and look for appropriate areas of application.

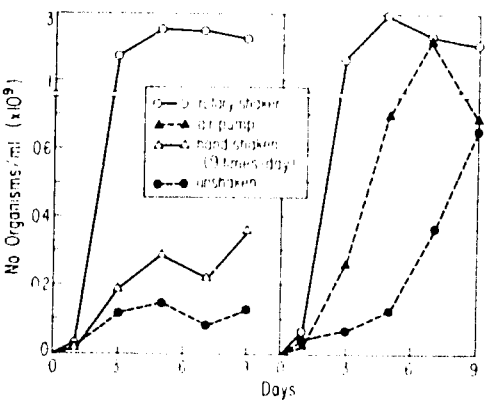


Fig. 2.
Plate counts of *Rhizobium japonicum* grown in liquid culture with various methods of aeration.

Effectiveness of Fast-Growing *Rhizobium japonicum* Strains Isolated from Nodules Collected in Vietnam

Introduction

Fast-growing *Rhizobium japonicum* strains have only been reported from the People's Republic of China (PRC). These strains reportedly inoculate only soybean varieties indigenous to PRC e.g., variety Peking. Nodules were collected by Dr. Joe Jackobs, INTSOY agronomist, during a trip to Vietnam in 1982. Isolates of *Rhizobium japonicum* were made from these nodules and they appeared to be of the fast-growing variety.

Methods and Materials

Pouch studies were conducted to determine the ability of the Vietnam isolates to noduiate with various varieties of soybean. Pouches were made with standard boilable plastic bags that were heat-sealed on three sides. Paper wicks were made from paper towels and inserted into the bag. The pouches were placed in a wire rack, half-filled with 25 ml of a minus nitrogen nutrient solution and sterilized in an autoclave.

Seeds of the desired varieties were sterilized and sprouted on moistened filter paper. *Rhizobium* strains were grown in liquid mannitol yeast extract media. The sprouted seeds were placed in the sterilized pouches and then inoculated with 0.5 to 1.0 ml of the appropriate *Rhizobium* strain. The rack was then placed under fluorescent and incandescent lamps. The

pouches were watered alternately with half-strength of minus nitrogen solution or sterile water throughout the experiment.

The experiment usually lasted for three to four weeks, at which time the plants were harvested and the nodules counted. Re-isolation of the organisms can be made from these nodules.

Results

Table 3 summarizes the interactions of soybean variety and *Rhizobium* strain. Twelve percent of the strains tested nodulated only variety Peking. Twelve percent of the strains showed no nodulation with any of the varieties tested. Thirty-six percent of the strains nodulated two varieties of soybean, and 12% nodulated three varieties.

North Carolina State University also tested the Vietnam isolates using the pouch method and found that 33% effectively nodulated Siratro. It was believed that the organisms were not similar to those found in RPC and that they were not the "typical" fast growers. They are presently running growth-chamber studies with different varieties of soybean.

Re-isolation of the organisms from nodules and planting them on solid media resulted in good growth in two days, which is typical of fast-growing *Rhizobium* strains.

Further discussions with North Carolina State University, as well as additional tests will be conducted to determine the status of the Vietnam isolates.

Table 3. Fast-growing *Rhizobium japonicum* strains isolated from nodules collected in Vietnam and their ability to form effective nodules on different varieties of soybean.

ISP#	Cultivar[z]							ISP#	Cultivar[z]						
	#1	#2	#3	#4	#5	#6	#7[y]		#1	#2	#3	#4	#5	#6	#7[y]
11						r	c	29						r	c
12						r	c	30	x						
13						r		31	x					r	
14		x				r	c	32						r	
15							c	33	x		x				c
16		x				r	c	34							
17		x					c	35					x	r	
19		x				r	c	38				x		r	
20		x				r	c	39	x				x	r	
21	x						c	40	x				x	r	
22								41			x			r	
23	x							42	x			x		r	
24	x							43						r	
25								44	x		x			r	
26	x							45				x		r	
27	x		x					46		x				r	
28															

[z]Cultivars: #1 = Peking (G4142); #2 = Peking (G4336); #3 = Alamo, #4 = Hill; #5 = Jupiter; #6 = Caribe.
x = fast-growing *Rhizobium* re-isolated from nodules.
r = fast-growing isolates from nodules being repeated.
c = confirmed by NCSU but considered not similar to isolates from PRC.
[y]Experiment done at North Carolina State University with Siratro.

Conclusion

Twelve percent of the strains nodulated only variety Peking, 36% nodulated two varieties, 12%, three varieties, and 12%, not any of the varieties.

Effect of the Interaction between *Rhizobium japonicum* Strains and *Azotobacter* Spp. on Soybean Growth and Nodulation

Introduction

Previous studies were done on the interaction of *Rhizobium japonicum* strains with *Azotobacter* spp. The work indicated clearly that with the proper selection of *Azotobacter* spp., enhanced nodule number and plant dry weight could be realized under laboratory conditions.

Rhizobium japonicum strain 184 (R.J. 184) has shown good heat tolerance in greenhouse studies at North Carolina State University and would be a good strain to eventually test under actual tropical conditions. It was, therefore, decided to try and find a strain of *Azotobacter* that would enhance nodulation and plant growth as has been previously shown.

Methods and Materials

Pouch studies, as previously described, were conducted with three strains of *Azotobacter* alone and in combination with R.J. 184. Four soybean cultivars (Alamo, Hill, Caribe, and Jupiter) were used to ascertain if variety was a factor in enhancing nodulation and plant growth.

Results

Overall, there appeared to be problems with nodulation on the pouch technique. It was obvious from the elongation of the stems that light was also a limiting factor, considering the density of soybean plants. There were cases with one replication nodulated and another not. Because of limited light, stem elongation was excessive.

There were some indications, however, that the combination of R.J. 184 and *A. beijerinckii* in the presence of Alamo and Hill provided three times as many nodules as R.J. 184 alone. There appeared to be an increase in both dry shoot weight and root weight for both Hill and Alamo (31% and 36%, 47% and 54%, respectively) above R.J. 184 alone. There was also very little difference between nodule mass, wet and dry.

Conclusion

It is felt that the pouch technique is not the best method for this type of study. Greenhouse studies, utilizing Leonard jars would be much more satisfactory. The results of this experiment are believed to be too variable to draw any valid conclusions. The indication of positive as well as negative influences in the interaction of *Rhizobium* × *Azotobacter* × *Cultivar* appeared to be present, but the current methodology was not satisfactory.

Illustrated Reference Cards for Identifying Nutrient Deficiencies and Diseases in Tomato

Introduction

AVRDC has been working on tomato for several years. There is enough information from soil science, pathology, entomology, and published literature to create a comprehensive and illustrated identification booklet dealing with nutrient deficiencies, diseases, and insect problems in tomato.

Methods and Materials

Pictures of tomato soil-nutrient deficiencies were copied from the July 1984 issue of *Organic Gardening**. Tomato disease photoraphs were obtained from the publication entitled *Identifying Diseases of Vegetables of the Pennsylvania State University* Photographs were mounted on heavy cardboard with titles. On the reverse side the disease or deficiency symptoms were described. The cards were then laminated with plastic to prevent soiling and water-staining in the field.

Results

The cards were made from photographs from literature and publications available in the library. The impact of a reference card or manual for tomato, as well as the other major AVRDC crops, is obvious.

Conclusion

AVRDC should place high priority on developing illustrations depicting the major nutrient deficiencies, diseases, and insect pests of the mandate crops. A field reference guide would greatly help LDCs in introducing intensive vegetable production programs and aid extension personnel in diagnosing problems correctly, thus, preventing unnecessary farm expenses.

* Foreman, K. 1984. Soil deficiencies. Organic Gardening 31(7): 36-41.

-371-

Soil Science

Effect of Nitrogen Fertilization on Soybean Growth

Introduction

Under good soybean management, symbiotic nitrogen fixation can supply up to 100 kg/ha of nitrogen (N), and make up over 50% of the total nitrogen uptake of soybean. Without additional nitrogen, the highest yield it can support is still only about 2 t/ha, but the application of nitrogen fertilizer suppresses nitrogen fixation. This experiment was designed, therefore, to find the optimum nitrogen concentration for both optimum and maximum yield.

Materials and Methods

The experiment was conducted in summer and autumn in the greenhouse. Smoked rice hulls which were used as a culture medium, were washed repeatedly with distilled water, packed into 1/5,000 are Wagner pots, and equilibrated with culture solution.

AGS129 seeds, inoculated with *Rhizobium japonicum* in advance, were sown on August 8, 1983 (summer trial) and on November 18, 1983 (autumn trial). Everyday, 900 ml of the culture solution was added to each pot drop by drop, and the leachate collected every three to four days for determination of pH and nitrogen uptake. The constituents of the culture solution are shown in Table 1.

Results

In the summer trial, soybean growth increased linearly with nitrogen concentration. Total dry weight, for example, increased by 5.043 g with every 1 meq increase of nitrogen application

Table 1. Correlation of selected growth parameters (Y) and nitrogen concentration (X) at flower initiation.

Selected Growth Parameter	Equation	Correlation Coefficient
Leaf dry. wt	$Y = 1.4146 + 0.0398 \times X$	0.5563
Stem dry wt	$Y = 0.7593 + 2.48 \times 10^{-3} \times X$	0.5729
Root dry wt	$Y = 0.4435 + 4.08 \times 10^{-4} \times X$	0.1775
Total dry wt	$Y = 2.8276 + 5.11 \times 10^{-5} \times X$	0.4535
Plant height	$Y = 24.6706 + 5.46 \times 10^{-3} \times X$	0.0996
Leaf area	$Y = 504.079 + 1.1524 \times X$	0.4710
Node no.	$Y = 8.2711 + 0.0138 \times X$	0.8638 *
Nodule no.	$Y = 43.6723 - 0.2158 \times X$	-0.6854
Nodule wt	$Y = 0.1467 - 1.14 \times 10^{-3} \times X$	-0.8910 *

* = significant at the 5% level.

(Fig. 1). Leaf area also increased by 550 cm^2; every 100 cm^2 increase of the leaf area produced another 1 g of dry matter. There is a linear correlation between leaf dry weight and leaf area: leaf area increased by 285 cm^2 with every 1 g increase of leaf dry weight Fig. 2).

A linear correlation was not found between N concentration and nodule formation (Fig. 3). A quadratic equation was fitted to each experimental point, and an optimum nitrogen concentration for the nodule formation was estimated by differentiating the equation. Optimum concentration lay in about 1.5 meq, and nodule formation was suppressed by both low and high rates of nitrogen application (Fig. 4). Soybean yield increased linearly with nitrogen application, but no correlation was seen between yield and nodule production.

In the autumn trial, most of the selected growth parameters did not correlate linearly with nitrogen concentration at the flower-initiation stage (Table 1). As seen in Figs. 4 and 5, the initial linear increase in nitrogen of up to 35 ppm is followed by a great decrease at 70 ppm, and then increased slightly again when 140 ppm of nitrogen was applied. Nodule number and dry weight, however, decreased logarithmically with nitrogen application (Fig. 6).

The effect of nitrogen concentration on nodule formation and yield are summarized in Table 2. For the calculation of the correlation coefficient, the experimental data in the range of 0 to 105 ppm N were used (that of 140 ppm was eliminated). Seed weight and number showed positive correlation with nitrogen application. However, unlike in the summer cultivation, they did not increase linearly, but logarithmically (Figs. 7 and 8); that is, yield response to nitrogen application was initially great, but carbohydrate production gradually became a limiting factor with increasing nitrogen level due to decreased light intensity and temperature.

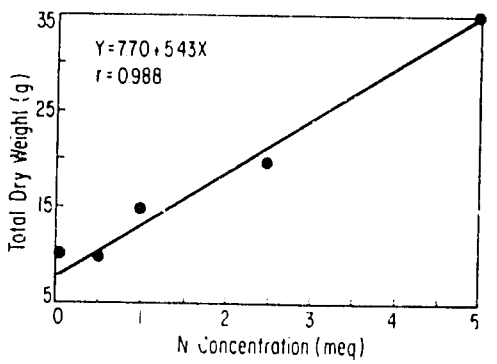


Fig. 1. Nitrogen concentration vs. total dry weight (g).

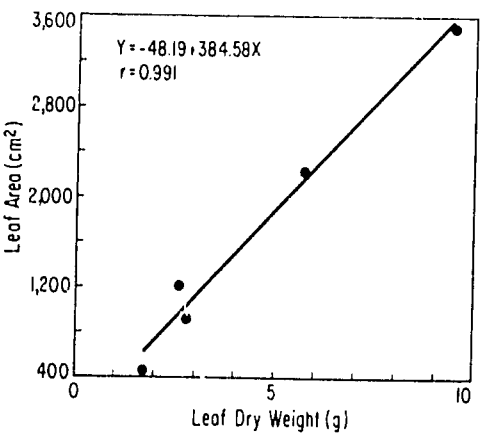


Fig. 2. Leaf dry weight vs. leaf area.

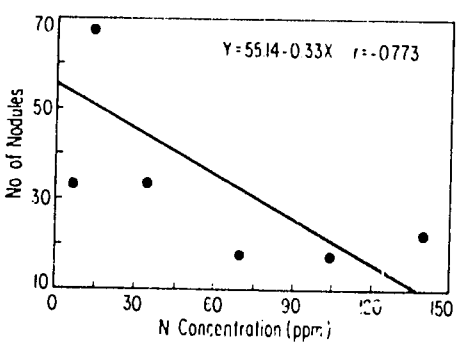


Fig. 3. Nitrogen concentration vs. nodule number at flowering stage.

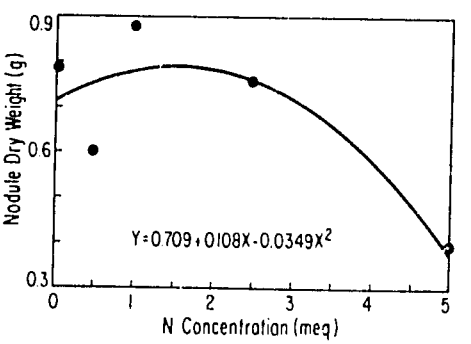


Fig. 4. Nodule dry weight vs. N concentration.

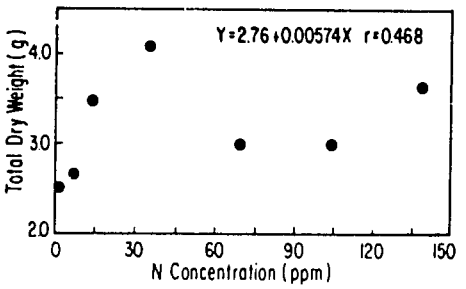


Fig. 5. Nitrogen concentration vs. total dry weight at flower initiation.

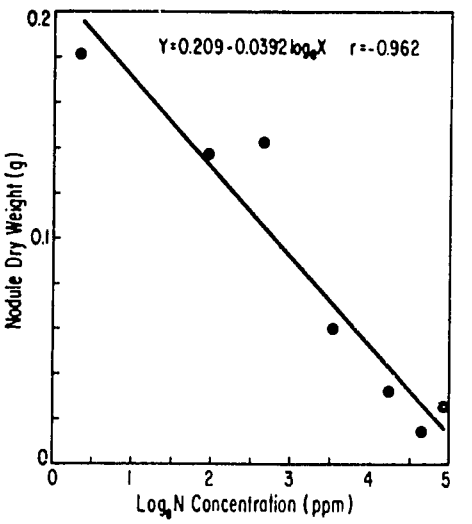


Fig. 6. Log (nitrogen concentration) vs. nodule dry weight.

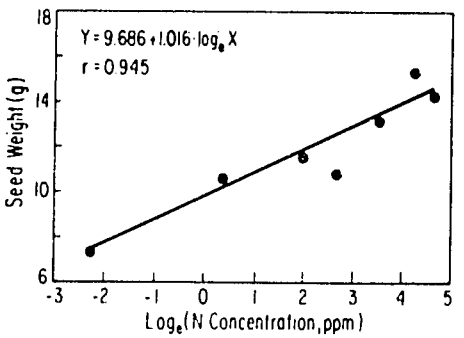


Fig. 7. Log (N concentration) vs. seed weight.

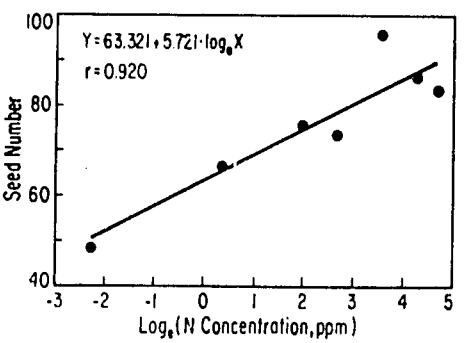


Fig. 8. Log (N concentration) vs. seed number.

Table 2. Correlation among nitrogen concentration, nodule formation, and yield.

Dependent (Y) and Independent Variables	Equation Fitted	Correlation Coefficient
Nodule no. 1[z] vs. N	Y = 49.9279 − 7.12984 logX	R = −0.9821*
Nodule wt. 1[z] vs. N	Y = 0.208973 − 0.03921 logX	R = −[illegible].3621*
Nodule no. 1 vs. seed wt.	Y = 101.704 − 0.7538X	R = −0.8802*
Nodule wt. 1 vs. seed wt.	Y = 16.6347 − 0.1376X	R = −0.9292*
Nodule no. 2[y] vs. N	Y = 0.534494 − 0.0962982 logX	R = −0.9099*
Nodule wt. 2[y] vs. N	Y = 0.383498 − (2.93364E − 03)X	R = −0.8957*
Nodule no. 2 vs. seed wt.	Y = 16.3043 − 0.104395X	R = −0.9120*
Nodule wt. 2 vs. seed wt.	Y = 15.236 − 12.6499X	R = −0.7620*
Seed wt. vs. N	Y = 9.68571 + 1.01647 logX	R = 0.9449*
Seed no. vs. N	Y = 63.3209 + 5.72101 logX	R = 0.9201*
Nodule no. at flower initiation vs. flowering stage	Y = 7.35716 + 1.01446X	R = 0.7837*
Nodule wt. at flower initiation vs. flowering stage	Y = 0.015883 + 2.52011X	R = 0.9704*

[z]At flower initiation stage. [y]At flowering stage. * = significant at the 5% level.

On the other hand, there was a distinctly negative correlation between nodule formation at the flower-initiation stage and nitrogen concentration. A similar correlation was also seen between nodule formation at the flowering stage and nitrogen application; the fitting was slightly inferior to that at the flower-initiation stage. Since logarithmic correlation was found between seed weight and nitrogen application; a negative linear correlation could be seen between nodule formation and seed weight (Fig. 9).

These facts indicate that nitrogen fixed through the nodule can not provide enough amount of nitrogen to support the reasonably high yield of soybean, so an adequate amount of nitrogen should be applied throughout the growth period to keep nitrogen concentration at medium high, even if nodule formation is suppressed by nitrogen application.

From the data obtained in the summer and autumn trials, the optimum nitrogen concentration for economical high yield was about 40 ppm. (Nodule formation was not suppressed greatly and plant growth was not retarded due to nitrogen deficiency.)

Conclusion

The amount of nitrogen fixed by nodule bacteria was not large enough to support the healthy growth of soybean. Though nitrogen application suppressed nodule formation, an adequate application of nitrogen was needed for high yield, as well as healthy growth of soybean. The optimum nitrogen concentration for economical high yield was about 40 ppm.

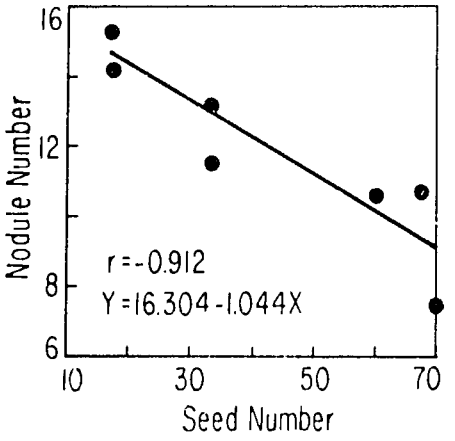


Fig. 9.
Seed number vs. nodule number at flowering stage.

Evaluation of Symbiotic Nitrogen Fixation of Soybean Isolines

Introduction

We have already reported that there is negative correlation between nitrogen fertilization and nodule formation, but the rate of nitrogen fixation is affected by various factors, such as nitrogen concentration, pH, Eh, EC, and water content in the medium. In addition, nodule activity varies with the growth stage of plants; therefore, it is very difficult to measure nitrogen fixation quantitatively at specific growth stages under different rates of nitrogen application. This project aimed to evaluate quantitatively the contribution ratio of symbiotic nitrogen fixation to total nitrogen uptake of soybean isolines.

Materials and Methods

The experiment was conducted in spring 1984. Soybean isolines, T201 (nonnodulating genotype), and T202 (nodulating genotype), inoculated with *Rhizobium japonicum* were sown on February 24, 1984. Everyday, 900 ml of the culture solution was added to each pot drop

by drop, and the leachate collected every three to four days for determination of pH and nitrogen uptake. The constituents of the culture solution are shown in Table 3.

Results

At 10 to 15 days after germination (DAG), T202 was relatively greener and taller than T201 in the plots applied with 0, 14 and 35 ppm N. The selected growth parameters at flowering stage are presented in Table 4. The results showed that there were no significant differences between the two isolines. The application of various nitrogen concentrations, however, gave a significant difference among the treatments. Regardless of genotype (nodulating or nonnodulating), the application of nitrogen was essential for better soybean growth in the initial growth stage. At this stage, a sufficient "source" should be guaranteed in order to get a sizable "sink", namely, yield. With increased nitrogen application, the parameters showing size of the source also increased steeply (see the columns on leaf number, weight and LAI in Table 2). For high yield, therefore, it is extremely important to keep nitrogen concentration relatively high in the medium before the flowering stage.

The effect of nitrogen concentration on soybean growth at pod-filling stage is presented in Table 5. Plant growth of the nonnodulating genotype was considerably retarded below 14 ppm N, but it was comparable to or even exceeded that of the nodulating genotype above 35 ppm N; that is, the contribution ratio of symbiotic nitrogen fixation to total nitrogen uptake decreased dramatically with the increase in nitrogen application. However, much more significant differences were noted in the growth parameters of soybean plants with different levels of nitrogen application. Again, therefore, the nitrogen level in the medium at the pod-filling stage was a primary factor for high yield, even if the nitrogen suppressed nodule formation.

Table 6 shows the selected growth and yield parameters at harvest. All the yield components were significantly different between T201 and T202 in the nitrogen range of 0 to 14 ppm. However, above 70 ppm N no difference was seen between them. So, as a whole, only seed number was significant.

On the other hand, all the yield components increased sharply with an increase in nitrogen application; so, soybean yield became significant among treatments. Vigorous vegetative growth due to high nitrogen application was attributed to a great increase in pod number. A continuous high supply of nitrogen until harvest secured enough amount of "source" for this sizable "sink". Hence, a heavy application of basal nitrogen followed by vigorous vegetative growth and suppression of nodule formation should always be accompanied by an adequate top dressing, in order to support smooth CO_2 fixation and its translocation to the "sink" at a later growth stage.

Correlation coefficients between yield components and nitrogen content in plant tissue at different growth stages is given in Table 7, 8, 9. Leaf area index (LAI) and dry weight of the whole plant at flowering stage highly correlated with yield components and, therefore, with yield. This fact indicates that it is very important to secure a large amount of "source" at an early growth stage for high yield.

Nitrogen content in the plant tissue is a good index of soybean yield. Increased nitrogen concentration, especially in leaves, accelerates photosynthetic carbon fixation, thus, making initial soybean growth more vigorous and yield higher. As in the flowering stage, both LAI

Table 3. Subtreatment (nitrogen levels).[z]

mg/liter	milli equivalent	ppm
0	0	0
40	1.0	14.0
100	2.5	35.0
200	5.0	70.0
400	10.0	140.0

[z]Source of nitrogen = NH_4NO_3 (28/80).

Table 4. Selected growth parameters at flowering stage, spring 1984.[z]

Treatment	Plant Height (cm)	Branch No.	Node No.	Leaf No.	LAI	Root Dry Wt (g)	Stem Dry Wt (g)	Leaf Dry Wt (g)	Total Dry Wt (g)
Main plot									
Variety									
T201 (nonnodulating)	30.85a	2.85b	8.15a	42.55a	1.12a	3.51a	5.76a	7.13a	16.40a
T202 (nodulating)	33.00a	3.15a	8.31a	44.15a	1.24a	3.17a	6.35a	8.64a	18.13a
LSD (.05)	9.53	0.25	3.18	49.55	0.36	2.54	4.45	2.41	3.94a
Subplot									
N level (ppm)									
0	21.75e	0.88b	5.88c	15.38d	0.27e	1.38d	1.90d	1.95d	5.15d
14	27.13d	1.88b	6.63c	26.38c	0.69d	3.03c	3.68c	4.88c	11.58c
35	35.25c	3.75a	8.88b	51.75b	1.39c	4.83a	7.28b	9.60b	21.70b
70	36.25b	4.13a	9.75ab	60.38a	1.69b	3.90b	8.38a	11.00a	23.48a
140	39.25a	4.38a	10.00a	62.88a	1.87a	3.58bc	8.85a	12.00a	24.43a
LSD (.05)	2.86	1.50	1.07	7.43	0.10	0.67	0.51	1.08	1.51

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

Table 5. Selected growth parameters at pod-filling stage, spring 1984.[z]

Treatment	Plant Height (cm)	Branch No.	Node No.	Pod No.	Leaf No.	LAI	Root Dry Wt (g)	Stem Dry Wt (g)	Leaf Dry Wt (g)	Pod Dry Wt (g)	Total Dry Wt (g)
Main plot											
Variety											
T201 (nonnodulating)	53.80a	2.84a	12.65a	40.00b	61.05a	1.96b	6.96a	19.86a	18.21a	14.00a	59.33a
T202 (nodulating)	61.15a	2.95a	13.90a	55.80a	67.85a	2.22a	6.61a	21.81a	20.21a	22.58a	71.21a
LSD (.05)	67.98	2.67	4.45	13.82	25.41	0.23	14.36	9.28	6.61	13.98	44.22
Subplot											
N level (ppm)											
0	31.50c	1.00d	9.75c	15.50e	21.88e	0.39e	3.33b	3.30e	4.58e	5.93e	17.13e
14	52.50b	2.25c	12.63b	34.25d	46.63d	1.20d	5.37b	11.48d	12.25d	12.23d	41.33d
35	69.13ab	3.00bc	13.38b	47.25c	65.38c	2.19c	8.00a	21.60c	19.78c	19.68c	69.05c
70	74.13a	3.98ab	14.75a	62.38b	83.88b	3.02b	8.38a	31.23b	26.65b	24.40b	90.65b
140	60.13ab	4.25a	15.88a	80.13a	104.50a	3.65a	8.85a	36.58a	32.80a	29.98a	108.20a
LSD (.05)	20.05	1.10	1.22	6.73	13.54	0.48	2.47	4.29	3.48	3.26	11.00

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

Table 6. Selected growth and yield parameters at harvest time, spring 1984.[z]

Treatment	Root Dry Wt (g)	Stem Dry Wt (g)	Leaf Dry Wt (g)	Pod Dry Wt (g)	Pod No.	Seed No.	100 Seed Wt (g)	Seed Dry Wt (g)	Total Dry Wt (g)
Main plot									
Variety									
T201 (nonnodulating)	5.77a	22.55a	18.99a	16.13a	38.80a	197.80b	13.68a	36.63a	100.12a
T202 (nodulating)	5.25a	26.03a	21.57a	20.25a	53.50a	254.20a	20.23a	52.92a	126.02a
LSD (.05)	6.61	37.36	16.01	13.47	24.14	40.66	16.14	38.92	111.72
Subplot									
N level (ppm)									
0	1.20d	3.08d	4.10e	4.13d	13.75e	57.75e	10.61d	10.19e	22.69e
14	3.68c	10.15c	9.95d	11.00c	29.88d	143.00d	13.80c	22.26d	57.04d
35	6.50b	21.48b	18.05c	19.23b	44.63c	215.00c	17.98b	39.38c	104.75c
70	8.53a	41.38a	31.28b	27.03a	64.63b	328.25b	20.27ab	66.53b	174.73b
140	7.65ab	45.38a	38.03a	29.58a	77.88a	386.00a	22.11a	85.52a	206.14a
LSD (.05)	1.30	4.17	4.27	3.15	7.60	33.79	2.82	8.87	19.60

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

Table 7. Correlation coefficients of yield components and nitrogen content in individual plant tissues at pod-filling stage.[z]

	Leaf N Content	Stem N Content	Root N Content	Pod N Content	LAI	Total Seed No.	Plant Dry Wt	100 Seed Wt	Yield
Leaf N	1.0000**	0.8620**	0.7188**	0.8975**	0.6656**	0.7061**	0.8013**	0.7677**	0.7205**
Stem N	0.8620**	1.0000**	0.8438**	0.7000**	0.4511*	0.4775*	0.5195*	0.5280*	0.5002*
Root N	0.7188**	0.8438**	1.0000**	0.5079*	0.4384ns	0.4650*	0.3524ns	0.5130*	0.4826*
Pod N	0.8975**	0.7000**	0.5079*	1.0000**	0.5431*	0.6100**	0.8399**	0.6547**	0.6216**
LAI	0.6656**	0.4511*	0.4384ns	0.5431*	1.0000**	0.9859**	0.7836**	0.9655**	0.9856**
Total seed no.	0.7061**	0.4775*	0.4650*	0.6100**	0.9859**	1.0000**	0.8354**	0.9758**	0.9994**
Plant dry wt	0.8013**	0.5195*	0.3524ns	0.8399**	0.7836**	0.8354**	1.0000**	0.8420	0.8372**
100-seed wt	0.7677**	0.5280*	0.5130*	0.6547**	0.9655**	0.9758**	0.8420**	1.0000**	0.9768**
Yield	0.7205**	0.5002*	0.4826*	0.6216**	0.9856**	0.9994**	0.8372**	0.9768**	1.0000**

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level.

Table 8. Correlation coefficients of yield components and nitrogen content in individual plant tissues at the flowering stage.[z]

	Leaf N Content	Stem N Content	Root N Content	Plant Dry Wt	LAI	100 Seed Wt	Total Seed No.	Yield
Leaf N	1.0000**	0.8595**	0.9058**	0.6205**	0.7376**	0.7755**	0.8444**	0.6755**
Stem N	0.8595**	1.0000**	0.8941**	0.4543*	0.5773**	0.5515*	0.7010**	0.5171*
Root N	0.9058**	0.8941**	1.0000**	0.5372*	0.6393**	0.6927**	0.7798**	0.5952**
Plant dry wt	0.6205**	0.4543*	0.5372*	1.0000**	0.9775**	0.7395**	0.9146**	0.9930**
LAI	0.7376**	0.5773**	0.6393**	0.9775**	1.0000**	0.7615**	0.9491**	0.9880**
100-seed wt	0.7755**	0.5515*	0.6927**	0.7395**	0.7615**	1.0000**	0.8420**	0.7645**
Total seed no.	0.8444**	0.7010**	0.7798**	0.9146**	0.9491**	0.8420**	1.0000**	0.9429**
Yield	0.6755**	0.5171*	0.5952**	0.9930**	0.9880**	0.7645**	0.9429**	1.0000**

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level.

Table 9. Correlation coefficients of yield components and nitrogen content in individual plant tissues at harvest.[z]

	Leaf N Content	Stem N Content	Root N Content	Pod N Content	Seed N Content	Plant Dry Wt	100 Seed Wt	Total Seed No.	Yield
Leaf N	1.0000**	0.9104**	0.4170ns	0.6148**	0.5701**	0.9164**	0.7526**	0.9087**	0.9189**
Stem N	0.9104**	1.0000**	0.5725**	0.5147*	0.5269*	0.8790**	0.7247**	0.8708**	0.8811**
Root N	0.4170ns	0.5725**	1.0000**	0.6622**	0.8073**	0.4803*	0.6749**	0.5397*	0.4789*
Pod N	0.6148**	0.5147*	0.6622**	1.0000**	0.7799**	0.5787**	0.6216**	0.6219**	0.5769**
Seed N	0.5701**	0.5269*	0.8073**	0.7799**	1.0000**	0.6273**	0.8594**	0.6917**	0.6236**
Plant dry wt	0.9164**	0.8790**	0.4803*	0.5787**	0.6273**	1.0000**	0.8170**	0.9910**	0.9997**
100-seed wt	0.7526**	0.7247**	0.6749**	0.6216**	0.8594**	0.8170**	1.0000**	0.8420**	0.8143**
Total seed no.	0.9087**	0.8708**	0.5397*	0.6219**	0.6917**	0.9910**	0.8420**	1.0000**	0.9912**
Yield	0.9189**	0.8811**	0.4789*	0.5769**	0.6236**	0.9997**	0.8143**	0.9912**	1.0000**

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level.

and total dry weight at the pod-filling stage are a very good index of soybean yield. Close correlation can be seen between nitrogen content in the plant tissues and yield.

Yield correlated well with all the parameters at harvest (Table 9). Regardless of genotype (nodulating or nonnodulating), nitrogen concentration in the plant tissues should be kept fairly high throughout the soybean growth period in order to obtain high yield. These results also indicate that nodule bacteroid cannot supply enough nitrogen to support vigorous soybean growth; therefore, basal nitrogen application is a primary factor for high yield and top dressing is necessary to keep nitrogen concentration in the soil high, thus, making nitrogen uptake by the plant more smooth in a later growth stage.

Tables 10 and 11 show the nitrogen concentrations in plant tissue and the different amounts of nitrogen given at flowering, pod-filling, and harvest stages. Nitrogen content was not significantly different between T201 and T202 throughout the growth stage. It did not vary significantly up to 35 ppm N in both T201 and T202. However, nitrogen accumulation in each plant tissue was influenced greatly by various rates of nitrogen application (Table 12, see p. 383). Each experimental point was also plotted ona graph for every critical growth period (Fig. 10 and 11.)

At the flowering stage, nitrogen was mainly accumulated in the leaves. The accumulation in the stem, however, increased steeply above 70 ppm. Leaves were also main accumulators of nitrogen at the pod-filling stage and a nearly linear relation could be found between nitrogen application rate and its accumulation in the leaves. The pod started storing nitrogen at this stage and nitrogen accumulation increased sharply with nitrogen application.

At harvest, more than 60% of nitrogen taken up was transferred to the seed, but nearly 20% (T201) and 16% (T202) of nitrogen were still stored in the leaves. Above 70 ppm N, leaves were still green and did not fall even just before harvest. These active leaves supported to produce the huge "source" and "sink". In Tables 5 and 6, leaf and pod numbers reached

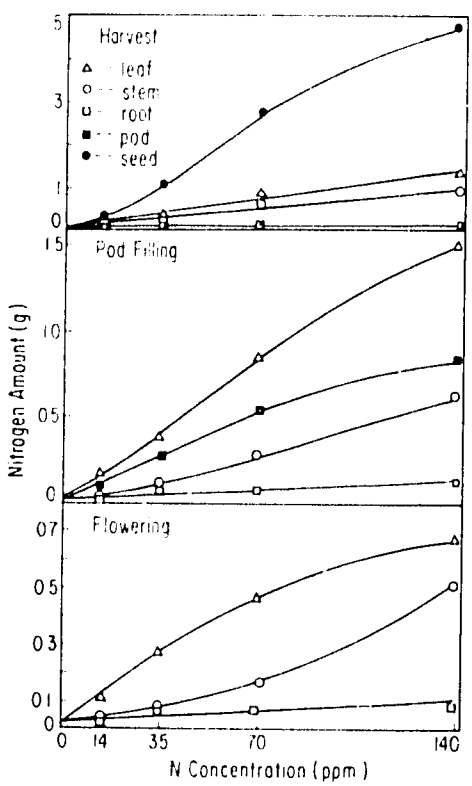


Fig. 10. Nitrogen uptake of T201 at different growth stages.

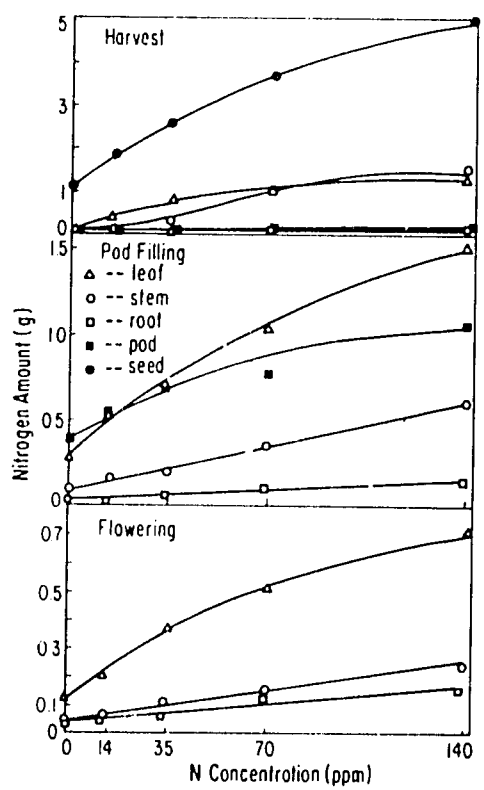


Fig. 11. Nitrogen uptake of T202 at different growth stages.

Table 10. Nitrogen concentration (%) in plant tissues as influenced by nitrogen application, spring 1984[z].

Variety	N Level (ppm)	Flowering Stage			Pod-Filling Stage				Harvest Stage				
		leaves	stems	roots	leaves	stems	roots	pods	leaves	stems	roots	hulls	seeds
T201	0	2.33a	1.22a	1.25a	1.76a	0.92b	1.07a	0.98a	2.05a	0.79a	0a	0a	0a
	14	2.67a	1.49a	1.40a	2.18a	0.58a	0.96a	1.87b	2.03a	0.48a	1.13b	0.51b	4.37b
	35	3.00a	1.17a	1.43a	1.99a	0.62a	0.83a	1.81b	2.18a	1.12ab	1.24b	0.35b	4.02b
	70	4.72b	2.09ab	1.88b	3.17b	0.89b	0.97a	2.53c	2.86b	1.64ab	1.18b	0.37b	4.58b
	140	5.84c	3.23c	2.21c	4.50c	1.58c	1.40b	2.93d	3.64c	2.13b	1.28b	0.82bc	5.75c
T202	0	4.10a	1.98a	1.85a	3.86a	1.47b	1.10a	3.35ab	2.21a	0.89a	1.65a	0.50a	5.43a
	14	3.67a	1.53a	1.61a	3.22a	0.97a	1.01a	2.89a	2.59b	1.33b	1.25a	0.44a	5.09a
	35	3.60a	1.54a	1.60a	3.33a	0.89a	1.04a	2.97a	2.86b	1.44b	1.42a	0.43a	5.20a
	70	4.26a	1.71a	1.68b	4.01a	1.13a	1.16a	3.28a	3.28c	2.49c	1.46a	0.48a	5.60a
	140	5.68b	2.78b	2.31c	4.89b	1.89c	1.87b	3.44ab	3.51c	2.71c	1.53a	0.62a	5.86a
LSD (.05)		0.96* (1.53)**	0.66 (1.20)	0.28 (1.21)	0.83 (1.38)	0.27 (0.40)	0.26 (1.86)	0.42 (0.40)	0.37 (1.46)	0.59 (0.53)	0.66 (2.19)	0.34 (0.63)	0.78 (2.14)

[z]Mean followed by the same letter in the same column are not significantly different at the 5% level, based on Duncan's Multiple Range Test. * = LSD for subplot treatments for the same main plot. ** = LSD for subplot treatments for different main plot.

Table 11. Nitrogen content (%) in plant tissues at different growth stages, spring 1984.[z]

Treatment	Flowering Stage			Pod Filling Stage				Harvest				
	leaves	stems	roots	leaves	stems	roots	pods	leaves	stems	roots	pods	seeds
Main plot												
Variety												
T201 (nonnodulating)	3.709a	1.873a	1.634a	2.722a	0.916a	1.047a	2.089b	2.551a	1.233b	1.020a	0.408a	3.742a
T202 (nodulating)	4.298a	1.907a	1.811a	3.861a	1.273a	1.238a	3.186a	2.980a	1.719a	1.563a	0.498a	5.442a
LSD (.05)	1.944	1.550	1.436	1.766	0.496	2.046	0.241	1.766	0.127	2.706	0.813	2.720
Subplot												
N level (ppm)												
0	3.215c	1.603bc	1.550c	2.805c	1.193b	1.088b	2.338b	2.128d	0.843d	0.963b	0.250b	2.718c
14	3.165c	1.510bc	1.505c	2.700c	0.775c	0.985b	2.375b	2.305cd	0.908cd	1.193ab	0.475b	4.728b
35	3.398c	1.355c	1.515c	2.660c	0.755c	0.930b	2.385b	2.523c	1.280c	1.328ab	0.395b	4.810b
70	4.488b	1.903b	1.780b	3.593b	1.013b	1.070b	2.905a	3.073b	1.930b	1.325ab	0.423b	4.903b
140	5.753a	3.080a	2.263a	4.700a	1.738a	1.640a	3.185a	3.575a	2.420a	1.650a	0.723a	5.803a
LSD (.05)	0.678	0.463	0.201	0.588	0.190	0.184	0.295	0.263	0.418	0.465	0.237	0.555

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

about 100 and 80, respectively. The stem worked mainly as a storage of excess nitrogen; the root did not accumulate nitrogen at any growth period.

Fig. 12 shows the changes in total nitrogen uptake by T202 and T201 with an increase in nitrogen application at three different growth stages. Experimental points were tested to fit various kinds of curves, and finally showed the best fit in a logistic curve. This curve is frequently used to predict the growth rate of a living thing. The maximum value of "y" in terms of entering a big value in "x" can easily be calculated. All the experimental points fitted the theoretical equation well.

It is noteworthy that a sizable amount of nitrogen was accumulated in the plant tissue after the pod-filling stage when more than 70 ppm of nitrogen was applied. In other words, a great amount of nitrogen must be supplied continuously after the pod-filling stage until harvest, in order to get extremely high soybean yield. For example, the maximum uptake of nitrogen by T202 at harvest was calculated to be 711 kg/ha on the following equation: $Y = 8.40/(1 + 4.2826*\exp(-0.5200*x))$.

On the other hand, the yield of T202 at infinite nitrogen concentration was 8.54 t/ha (Fig. 13) on this equation: $Y = 87.80/(1 + 2.780*\exp(-0.5191*x)$. Potential yield of T202 under this experimental condition (plant population: approximately 85,000/ha, two plants/hill) was 8.54 t/ha; and 711 kg/ha of nitrogen should be absorbed to attain this yield level. Then, 440 kg/ha of nitrogen was accumulated in the seed, that is, nearly 62% of total nitrogen uptake was transferred to the seed (Fig. 14).

Similarly in T201, for 8.56 t/ha of the yield, 660 kg N/ha and 440 kg N/ha were absorbed in the whole plant tissue and seed, respectively. At the pod-filling stage, 330 kg N/ha and 270 kg N/ha should be absorbed for the maximum yield of T202 and T201, respectively, while at the flowering stage 114 kg N/ha and 95 kg N/ha for T202 and T201, respectively, should likewise be taken in.

From two theoretical equations for T202 and T201, we can evaluate symbiotic nitrogen fixation of the different growth stages at any nitrogen concentration. Nitrogen fixation increases slightly with an increase in the nitrogen concentration of up to 30 ppm and then, it decreases. The results agreed well with the data shown in Fig. 15. Increased nitrogen application brought about a linear decrease in nodule number at flowering stage, while nodule weight reached its maximum at 14 ppm N and slightly declined up to 35 ppm N, its great loss occurring above 70 ppm N.

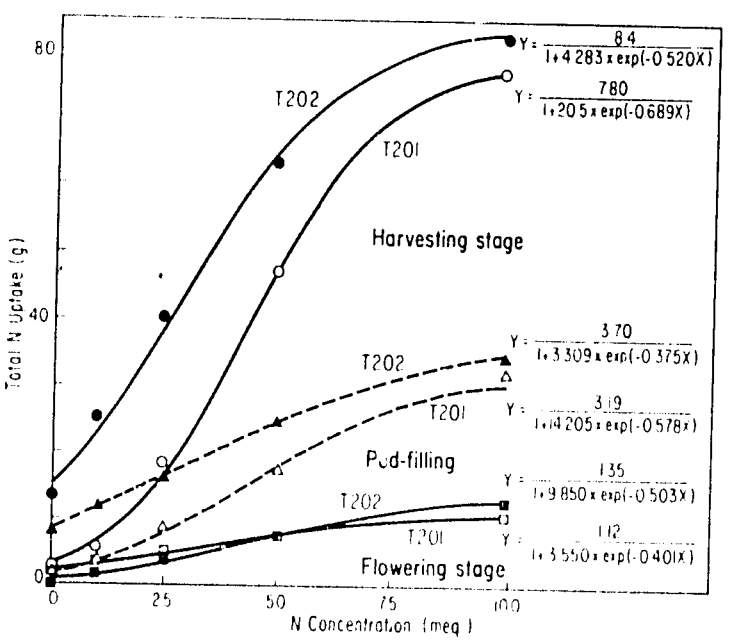


Fig. 12. N-concentration vs. total nitrogen uptake.

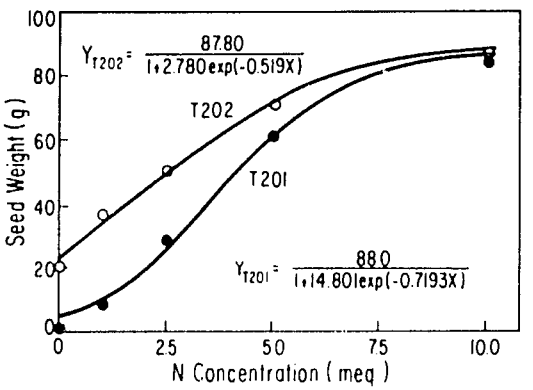


Fig. 13. N-concentration vs. seed weight.

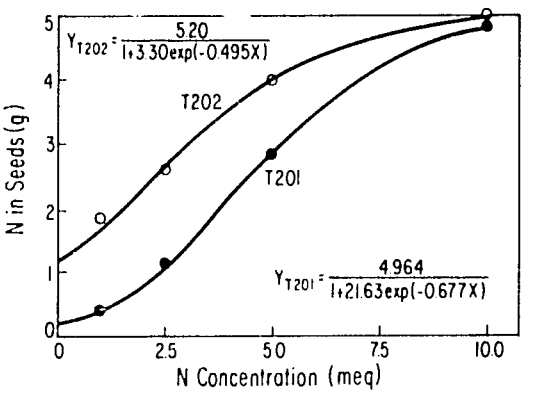


Fig. 14. N concentration vs. N contained in the seed.

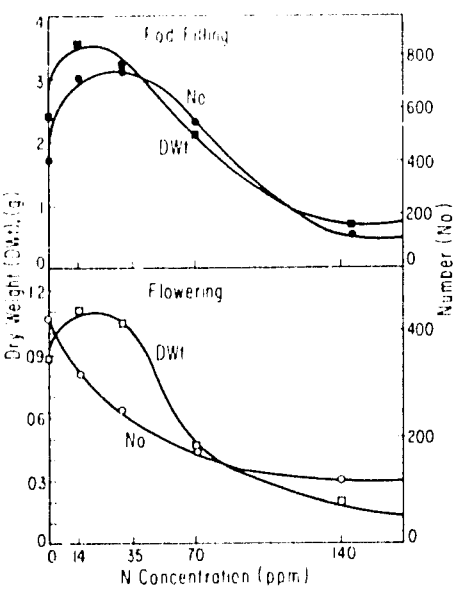


Fig. 15.
Weight and number of nodules as influenced by level of nitrogen at flowering and pod-filling stages.

At pod-filling stage, plants treated with 14 ppm N obtained the heaviest nodule dry weight; and plants that received 35 ppm N garnered the highest nodule number. It has been widely accepted that increased nitrogen application suppressed nodulation and that utilization of atmospheric nitrogen by soybean is usually reduced when inorganic nitrogen is added to the rooting medium. However, our results showed that the addition of low nitrogen levels resulted in vigorous nodulation and nitrogen fixation. Nitrogen application is, therefore, really necessary to support initial healthy growth of soybean and the consequent high yield.

Finally, the contribution of symbiotic nitrogen fixation to total nitrogen uptake is calculated and presented in Table 13. The contribution sharply decreased with increasing nitrogen application, and about 50% of nitrogen uptake was fixed symbiotically when 35 ppm N was supplied. The final column in Table 13 shows how much nitrogen is needed to produce 1 t/ha of soybean yield. The nitrogen requirement for 1 t of seed was smallest at 14 ppm N and increased with increasing nitrogen concentration. Thus, nitrogen fixation was accelerated when less than 14 ppm of nitrogen was supplied. However, the initial growth of soybean was fairly retarded, resulting in a great decrease of soybean yield. Therefore, 35 ppm N at which contribution of symbiotic nitrogen fixation to the total nitrogen uptake exceeds 50% and initial growth retardation of soybean plant is negligible, is considered to be an adequate concentration for an economic high yield.

Table 12. Nitrogen uptake (g/2 plants) of T201 and T202 at different growth stages.[z]

Genotype	N level (ppm)	Flowering Stage				Pod-Filling Stage					Harvest					
		leaves	stems	roots	total	leaves	stems	roots	pods	total	leaves	stems	roots	hulls	seeds	total
T201	0	0.021	0.017	0.015	0.053	0.032	0.001	0.041	0.001	0.075	0.025	0.006	0	0	0	0.031
		(39.6)	(32.1)	(28.3)		(42.7)	(1.3)	(54.7)	(1.3)		(80.7)	(19.4)	(0.0)	(0.0)	(0.0)	
	14	0.109	0.051	0.043	0.204	0.183	0.041	0.005	0.110	0.339	0.132	0.028	0.010	0.031	0.358	0.559
		(53.4)	(25.0)	(21.1)		(54.0)	(12.1)	(1.5)	(32.5)		(23.6)	(5.0)	(1.8)	(5.6)	(64.0)	
	35	0.273	0.082	0.084	0.439	0.392	0.128	0.070	0.291	0.881	0.349	0.200	0.088	0.060	1.154	1.851
		(62.3)	(18.7)	(19.1)		(44.5)	(14.5)	(8.0)	(33.0)		(18.9)	(10.8)	(4.8)	(3.2)	(62.3)	
	70	0.477	0.169	0.071	0.717	0.850	0.279	0.079	0.524	1.732	0.927	0.689	0.119	0.101	2.820	4.656
		(66.5)	(23.6)	(9.9)		(49.1)	(16.1)	(4.6)	(30.3)		(19.9)	(14.8)	(2.6)	(2.2)	(60.6)	
	140	0.677	0.514	0.084	1.275	1.548	0.627	0.130	0.841	3.146	1.420	0.986	0.110	0.248	4.865	7.629
		(53.1)	(40.3)	(6.6)		(49.2)	(19.9)	(4.1)	(26.7)		(18.6)	(12.9)	(1.4)	(3.3)	(63.8)	
T202	0	0.127	0.046	0.030	0.203	0.286	0.087	0.032	0.395	0.800	0.157	0.048	0.036	0.041	1.097	1.379
		(62.6)	(22.7)	(14.8)		(35.8)	(10.9)	(4.0)	(49.4)		(11.4)	(3.5)	(2.6)	(3.0)	(79.6)	
	14	0.209	0.061	0.048	0.318	0.518	0.154	0.005	0.538	1.215	0.350	0.193	0.056	0.070	1.853	2.522
		(65.7)	(19.2)	(15.1)		(42.6)	(12.7)	(0.4)	(44.3)		(13.9)	(7.7)	(2.2)	(2.8)	(73.5)	
	35	0.388	0.117	0.061	0.565	0.663	0.201	0.079	0.692	1.635	0.861	0.361	0.084	0.092	2.600	3.998
		(68.7)	(20.7)	(10.8)		(40.6)	(12.3)	(4.8)	(42.3)		(21.5)	(9.0)	(2.1)	(2.3)	(65.0)	
	70	0.507	0.156	0.069	0.732	1.063	0.352	0.101	0.922	2.438	0.991	1.016	0.102	0.129	4.010	6.248
		(69.3)	(21.3)	(9.4)		(43.6)	(14.4)	(4.1)	(37.8)		(15.9)	(16.3)	(1.6)	(2.1)	(64.2)	
	140	0.704	0.245	0.079	1.028	1.531	0.633	0.159	1.073	3.396	1.302	1.612	0.103	0.180	5.063	8.260
		(68.5)	(23.8)	(7.7)		(45.1)	(18.6)	(4.7)	(31.6)		(15.8)	(19.5)	(1.3)	(2.2)	(61.3)	

[z]Numerical values in parenthesis show the percentages of the total uptake.

Table 13. Effect of N concentration on contribution of N fixation to total uptake.

N level (ppm)	Contribution of N fixation (% of total uptake)			N Absorbed (kg/ha)	Yield (t/ha)	N Required to Produce 1 t/ha Dry Matter (kg/ha)
	flowering	pod-filling	harvest			
0	73.9	90.6	97.8	116.7	1.72	67.80
14	35.8	72.1	77.8	213.5	3.40	62.80
35	22.3	46.1	53.7	338.5	4.93	68.66
70	2.0	29.0	25.5	528.9	7.17	73.76
140	0.0	7.4	7.7	699.3	8.33	83.95

Again, this fact agrees completely with the results obtained in previous two experiments on a Center's cultivar, AGS 129. Our results also showed that nitrogen uptake increased greatly during flowering and pod-filling. So, it is important that basal dressing of nitrogen should not exceed the critical nitrogen concentration (35 ppm N), and that top dressing at one week or 10 days after flower initiation should be applied to achieve a high economic soybean yield.

Conclusion

Logistic curves were the best fit for each experimental point in seed production and nitrogen uptake of soybean isoline, T201 and T202. From theoretical equations, the potential yield of T202 (nodulation genotype) was estimated to be 8.54 t/ha, which can be achieved with the application of 711 kg/ha of nitrogen. This resulted in the accumulation of 440 kg N/ha in the seed, which was nearly 60% of the total nitrogen uptake.

Although the contribution ratio of symbiotic nitrogen fixation to total nitrogen uptake sharply decreased with increasing nitrogen application, it was confirmed that 35 ppm N gave the economic maximum soybean yield and the contribution ratio exceeded 50% at this concentration.

The addition of low nitrogen levels resulted in vigorous nodulation and nitrogen fixation. So, a basal dressing of nitrogen is highly recommended, but it should not exceed the critical nitrogen concentration of 35 ppm. Also, top dressing at one week or 10 days after flower initiation is recommended for a high economic yield of soybean.

Rational Nitrogen Fertilization for Soybean

Introduction

It was clarified that 35 ppm N gave the maximum economic yield of soybean and that the contribution of symbiotic nitrogen fixation to the total nitrogen uptake exceeded 50% at this concentration. Our results also showed that nitrogen uptake increased greatly during flowering and pod-filling. Hence, we proposed an adequate basal dressing of 35 ppm N and a top dressing at one week or 10 days after flower-initiation. This project investigated the response of soybean to nitrogen fertilization at different growth periods, and to find a rational nitrogen fertilization for a high economic soybean yield.

Material and Methods

A pot experiment was conducted in the greenhouse in autumn 1984. Soybean isolines, T201 and T202, were sown on September 24, 1984. Seeds germinated on September 30, 1984 and the plants harvested on December 13, 1984. Treatments are summarized in Fig. 16.

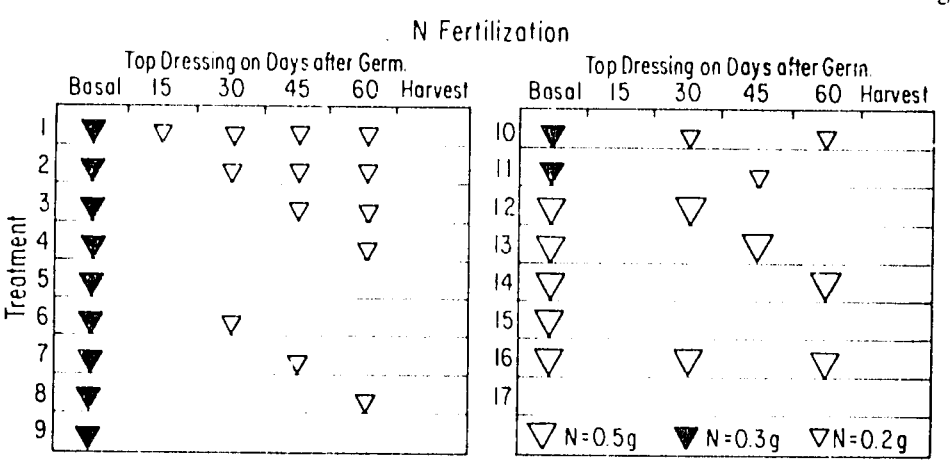


Fig. 16. Nitrogen fertilization of soybean isolines T201 and T202.

Results

The effect of nitrogen applied at different growth stages on selected growth parameters and yield components of soybean isoline is summarized in Table 14. Pod number increased greatly with the application of nitrogen at 30 days after germination (DAG) (Treatments 1, 2, 10, and 12). If the application rate of basal nitrogen is low, top dressing should be conducted before and/or at flower-initiation time. Top dressing at 45 DAG did not increase pod number. Table 15 shows the fact very clearly. In T201 (nonnodulating genotype) all the treatments which received nitrogen at 30 DAG gave a much higher pod number than the other treatments which received no top dressing at pod-initiation stage or later.

The last column of Table 15 shows the contribution of symbiotic nitrogen fixation to total nitrogen uptake. The treatments which did not receive nitrogen top dressing at 30 DAG showed great numerical values. In other words, a great loss of pod number occurred when nitrogen was not applied at 30 DAG. Therefore, top dressing at 30 DAG combined with an adequate basal dressing is very important to secure enough pod number. It is noteworthy that optimum top dressing time lies at around the pod-initiation stage.

When a relatively high rate of nitrogen was applied as basal, 100-seed weight increased considerably. Nitrogen top dressing at either 30 DAG or 45 DAG was best when basal nitrogen was relatively low. Seed weight was greatly recovered, but still there was a sizable difference between T201 and T202 – 50% greater in T202-(Table 16). Therefore, a continuous supply of nitrogen at a relatively low rate throughout its growth stage and a top dressing at either 45 DAG or 30 DAG produce the heaviest seed weight.

There is a significant difference in seed weight between T201 and T202 – 60% greater in T202. The treatments with nitrogen at 30 DAG gave extremely high yields (Table 17). Plants which received 0.3 g of basal nitrogen, but no top dressing produced 3.6 g/plant (No. 5), but the plants which received another 0.2 g N at 30 DAG produced 7.0 g/plant. Hence, a 100% increase in soybean yield resulted from the top dressing at 30 DAG (No. 6). When 0.5 g each of nitrogen was applied as both basal and top dressings at 30 DAG, a further 50% increase in yield over the 0.3 g N application resulted (No. 12). Thus, nitrogen application at 30 DAG is a key factor in the substantial increase of soybean yield.

Conclusion

To increase pod number of soybean greatly, both basal and top dressing of nitrogen at 30 DAG are very important. Since hundred-seed weight is governed mainly by the nitrogen status at a later growth stage, i.e., pod-initiation stage, nitrogen top dressing at 45 DAG is necessary. To obtain high soybean yield, the combination of a relatively high rate of nitrogen application of both basal and top dressings at 30 DAG, or the application of a relatively low nitrogen rate at each critical time, that is, at basal, flower-initiation (30 DAG), and pod-initiation (45 DAG), is highly recommended.

Effect of Time, Form, and Concentration of Nitrogen Application on Chinese Cabbage Tipburn

Introduction

Recently, soil science laboratory at AVRDC confirmed that ammonium toxicity was a primary factor in the cause of Chinese cabbage tipburn. Calcium (Ca) deficiency, which was considered a cause of tipburn, was brought about by water stress due to root damage by ammonium nitrogen. In addition, internal rot is also caused by nitrogen excess, regardless of Ca application level. So, we recommended deep plowing, organic material application, and split application of nitrogen as practical soil and fertilizer management.

Table 14. Selected growth parameters and yield components of T201 and T202, autumn 1984.[z]

	Plant Height (cm)	Leaf Dry Wt (g/2 plants)	Total Dry Wt (g/2 plants)	Node No. per plant	Pod No. per plant	Seed Dry Wt (g/2 plant)	100-Seed Wt (g)	No. Seeds/ Pod
Main Plot Cultivar								
T201	36.5a	3.16b	18.49b	7.89a	11.04b	6.13b	12.08b	2.24a
T202	35.9a	4.53a	24.10a	8.26a	12.30a	10.05a	18.31a	2.25a
LSD (.05)	1.7	0.34	0.31	0.95	0.48	0.29	1.72	0.21
Subplot Fertilization								
No. 1	36.9a	4.40ab	27.90a	9.00a	16.25a	10.85ab	14.85cd	2.25abc
2	36.6a	3.90a-d	22.32bcd	8.00cd	13.75bc	8.52d-g	14.34cde	2.16abc
3	36.4a	4.63a	22.01cde	7.88cd	10.25gh	7.71ghi	18.10a	2.08bc
4	36.6a	3.48cd	18.88g	7.88cd	10.89fgh	6.88i	13.73def	2.25abc
5	36.9a	3.38cd	19.26g	7.75d	10.00h	6.61i	13.34ef	2.34ab
6	36.3a	3.70bcd	22.88bc	8.13bcd	13.63bcd	8.90def	15.34c	2.14abc
7	37.0a	4.23abc	21.96cde	8.00cd	10.75fgh	8.08fgh	16.89ab	2.20abc
8	36.3a	3.53bcd	19.52fg	8.00cd	10.50fgh	6.72i	13.90def	2.31abc
9	36.5a	4.13a-d	19.80efg	7.75d	10.50fgh	7.00hi	14.51cde	2.27abc
10	35.9a	3.83a-d	22.01cde	8.13bcd	13.88b	8.99def	14.86cd	2.17abc
11	36.6a	3.90a-d	21.75c-f	7.88cd	9.88h	8.27efg	17.28ab	2.38ab
12	36.0a	4.68a	27.18a	8.38bc	14.25b	11.41a	17.45ab	2.31abc
13	36.4a	4.05a-d	23.09bc	8.00cd	12.13c-f	9.56cd	16.86ab	2.32ab
14	37.3a	3.80a-d	19.73efg	8.63ab	11.75efg	7.35ghi	14.18cde	2.21abc
15	34.6a	3.58bcd	20.25d-g	8.25bcd	13.38b-e	7.55ghi	13.38ef	2.12bc
16	36.4a	4.13a-d	24.39b	8.38bc	12.75b-e	10.19bc	17.62ab	2.31abc
17	31.1b	2.48e	12.34h	6.63e	7.50i	4.36j	12.69f	2.02c
LSD (.05)	3.13	0.74	2.05	0.48	1.47	1.06	1.19	0.25

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

Table 15. The effect of nitrogen fertilization on pod number of soybean isolines T201 and T202.[z]

Treatment	T201	T202	T202 – T201	$\frac{T202 - T201}{T201} \times 100$	Treatment	T201	T202	T202 – T201	$\frac{T202 - T201}{T201} \times 100$
No. 1	16.75a	15.75a	– 1.00	– 6.0	No. 10	14.00bc	13.75ab	– 0.25	– 1.8
2	13.25bc	14.25ab	1.00	7.5	11	9.75d	10.00c	0.25	2.6
3	9.75d	10.75c	1.00	10.3	12	14.50b	14.00ab	– 0.50	– 3.4
4	10.50cd	11.25bc	0.75	7.1	13	12.00cd	12.25bc	0.25	2.1
5	8.75d	11.25bc	2.50	28.6	14	11.50cd	12.00bc	0.50	4.3
6	13.25bc	14.00ab	0.75	5.7	15	12.25c	14.50ab	2.25	18.4
7	9.75d	11.75bc	2.00	20.5	16	12.50bc	13.00b	0.50	4.0
8	9.25d	11.75bc	2.50	27.0	17	5.00c	10.00c	5.00	100.0
9	8.75d	12.25bc	3.50	40.0	LSD (.05)	2.07			

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

This project aimed to study the toxic effect of ammonium nitrogen on Chinese cabbage tipburn in more detail and to find a rational soil and fertilizer management for Chinese cabbage cultivation in summer season. In this experiment, the relationship between Chinese cabbage tipburn and the time, form, and concentration of nitrogen application was especially examined.

Table 16. The effect of nitrogen fertilization on 100-seed weight of soybean isolines T201 and T202.[z]

Treatment	T201	T202	T202 – T201	$\frac{T202 - T201}{T201} \times 100$
No. 1	12.500 bc	17.200 cd	4.700	37.6
2	11.025 c	17.435 cd	6.410	58.1
3	14.100 b	22.100 a	8.00	56.7
4	9.255 d	18.205 c	8.95	96.7
5	9.025 d	17.650 cd	8.625	95.6
6	11.920 c	18.760 bc	6.84	57.4
7	13.255 bc	20.525 ab	7.27	54.8
8	9.180 d	18.615 bc	9.435	102.8
9	9.115 d	19.895 b	10.78	118.3
10	11.960 c	17.760 cd	5.80	48.5
11	14.095 b	20.465 ab	6.37	45.2
12	16.835 a	18.060 cd	1.225	7.3
13	17.330 a	16.395 d	–0.935	–5.4
14	10.440 cd	17.910 cd	9.47	71.6
15	10.080 cd	16.685 cd	6.605	65.5
16	17.355 a	17.880 cd	0.525	3.0
17	8.510 d	16.865 cd	8.355	98.2
LSD (.05)	1.683			

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

Table 17. The effect of nitrogen fertilization on seed weight of soybean isolines T201 and T202.

Treatment	T201	T202	T202 – T201	$\frac{T202 - T201}{T201} \times 100$
No. 1	9.209 b	12.483 a	3.274	35.5
2	6.383 cd	10.660 b	4.277	67.0
3	5.888 cd	9.530 bc	3.642	61.9
4	4.199 de	9.551 bc	5.352	127.5
5	3.563 e	9.660 bc	6.097	171.1
6	7.065 c	10.742 b	3.677	52.0
7	5.835 cd	10.335 bc	4.500	77.1
8	3.647 e	9.792 bc	6.145	62.8
9	3.948 de	10.050 bc	6.102	154.6
10	7.066 c	10.910 b	3.844	54.4
11	5.947 cd	10.599 bc	4.652	78.2
12	10.994 a	11.819 ab	0.825	7.5
13	9.980 ab	9.141 c	–0.839	–8.4
14	5.284 d	9.418 bc	4.134	78.2
15	5.630 cd	9.478 bc	3.848	68.3
16	10.305 ab	10.082 bc	–0.223	–2.2
17	1.616 f	7.110 d	5.494	340.0
LSD (.05)	1.495			

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

Materials and Methods

The experiment was conducted in the spring and summer of 1984. Chinese cabbage was cultivated on the same apparatus and same culture solution, except for nitrogen treatment as in the previous work. Treatments and composition of culture solution are presented in Fig. 17 and Table 18, respectively. Seedlings of Chinese cabbage cultivar, F1 hybrid #62 which had been grown in a smoked rice-hull medium containing the culture solution were transplanted on April 13, 1984 and harvested on May 25, 1984. The duration time up to harvest was 42 days.

Results

Symptoms of NH_4-N toxicity. All plants fed with NH_4-N from the beginning started to change leaf color to dark green from six days after treatment (DART). Several days before tipburn symptoms appeared, the plants began wilting from late morning to the afternoon and

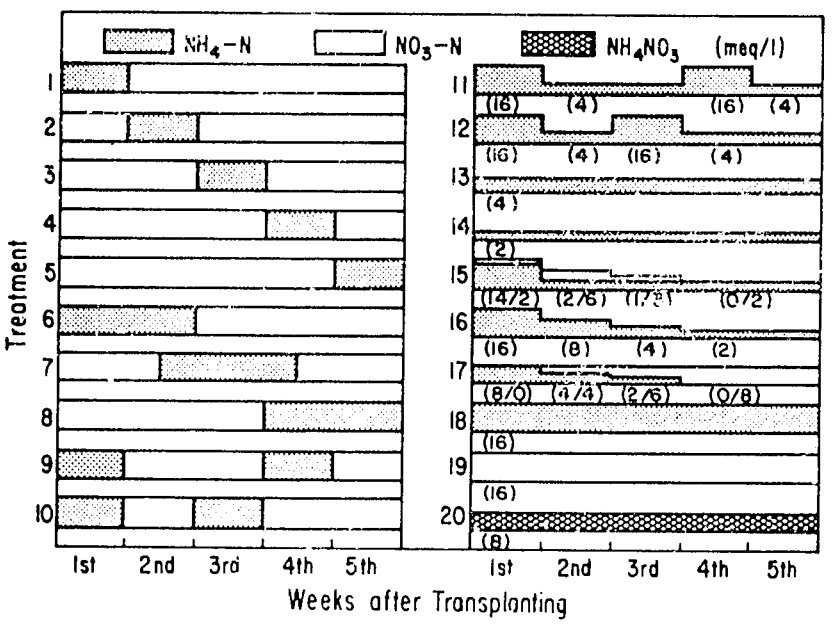


Fig. 17. Nitrogen treatments in the second experiment. Numerical values in parenthesis show nitrogen concentration in meq/1.

Table 18. Composition of nutrient solution.

Element	Chemical Reagents	Concentration
NH_4-N	$(NH_4)_2SO_4$	224 ppm (16 meq/l)
NO_3-N	$Ca(NO_3)_2 \cdot 4H_2O$, KNO_3, $Mg(NO_3)_2 \cdot 6H_2O$	" " "
NH_4NO_3	NH_4NO_3	112 " (8 ")
K	K_2SO_4, KNO_3	312 " (8 ")
Ca	$CaCl_2 \cdot 2H_2O$, $Ca(NO_3)_2 \cdot 4H_2O$	160 " (8 ")
Mg	$MgSO_4 \cdot 7H_2O$, $Mg(NO_3)2 \cdot 6H_2O$	49 " (4 ")
P	K_2HPO_4	41 "
Fe	Fe-EDTA	3 "
Mn	$MnSO_4 \cdot H_2O$	0.5 "
B	H_3BO_3	0.5 "
Zn	$ZnSO_4 \cdot 7H_2O$	0.05 "
Cu	$CuSO_4 \cdot 5H_2O$	0.02 "
Mo	$Na_2MoO_4 \cdot 2H_2O$	0.01 "

recovered by night. A slight tipburn symptom appeared at 10 DART and then developed continuously, resulting in a great loss of Chinese cabbage head yield. Treatment 14 in which the plant received 28 ppm of NH_4-N, showed N deficiency symptoms.

Although 160 ppm of Ca was supplied to all the treatments, tipburn developed only on plants treated with NH_4-N. This showed that tipburn was caused by ammonium toxicity rather than by Ca deficiency. It was also confirmed in this experiment that there was a great varietal difference in sensitivity to ammonia toxicity. In a previous experiment tipburn symptoms showed several days earlier in Fong-Luh, and were more severe than in #62.

Similar symptoms were found in roots. Roots of plants grown with NH_4-N were short, darkened, lignified, easily broken, and sometimes turned purplish in color. Roots fertilized with NO_3-N were long, slender, white, numerous, and hairy.

Influences of nitrogen source on yield. Plants grown with NH_4-N throughout the growth period irrespective of concentration had the lowest yields (Fig. 18). On the other hand, plants in treatments 1, 17, and 19 showed healthy growth and gave very high yields. Those that received 16 meq NO_3-N throughout the growth period (treatment 19) produced the second highest yields. In treatment 1, NH_4-N was applied to the plants only in the first week, and afterwards, the nitrogen source was switched from ammonia to nitrate. In this treatment were found the highest total and head yields.

In treatment 17, ammonia concentration started with 8 meq, which was reduced every week to half of that in the previous week; but nitrate concentration was increased by 2 meq every week, keeping the total nitrogen concentration (sum of ammonia and nitrate) at 8 meq. In this treatment, there was a slightly higher total yield than in treatment 19. This seems to indicate that ammonia is superior to nitrate in accelerating plant growth, unless the former exerts a severe harmful effect on plant roots.

In treatments 1 to 5, the application of ammonia was shifted to the later growth stage by one week. As the growth stage advanced, however, ammonia exerted a more severe harmful effect. In addition to the resulting great loss in yield, tipburn symptoms appeared on the young leaves only of plants receiving ammonia in the third week (treatments 3, 7, 10, and 11 to 18) (Table 19).

Since head formation started two weeks after treatment (WATR), it indicated that the head-formation stage was the most sensitive to tipburn, that is, Chinese cabbage easily suffered from tipburn if NH_4-N is applied at this stage. Plants receiving ammonia at the 4th WATR suffered much greater yield losses than those at the 3rd WATR (treatments 4, 7, and 11). So, the week after head initiation is the critical period for high yield.

A comparison of treatment 9 with 11 or 10 with 12 showed that yield recovery was much greater when ammonia was changed to nitrate than when ammonia concentration was decreased to one-fourth of the initial concentration. According to the results of treatment 18, 13, and 14 (NH_4-N was supplied at a rate of 16 meq, 4 meq, and 2 meq, respectively), even an NH_4-N concentration as low as 28 ppm still produced tipburn symptoms. This indicates that, as far as tipburn is concerned, the kind of nitrogen source is more important than the rate of application.

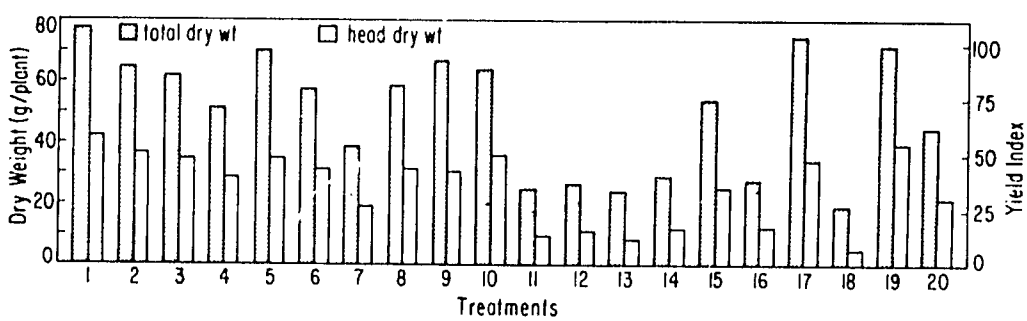


Fig. 18. Effect of time, form, and nitrogen concentration on total and head dry weights.

Table 19. CaO contents in the leaves and frequency of tipburn and internal rot in ASVEG #1.

Treat-ment	CaO % (dry wt basis)								Internal Rot[z]	Tip-burn[z]
	head	blade	head	midrib	outer	blade	outer	midrib		
1	0.27	ab	1.20	a	7.07	ab	3.03	ab	**	
2	0.18	cdef	1.18	a	6.66	abc	3.27	abc	****	
3	0.18	cdef	1.17	a	6.56	abcd	3.01	bcd	***	**
4	0.23	bc	1.05	abc	7.23	a	3.60	a	****	
5	0.19	cde	0.87	d	6.25	cdef	2.94	bcd	****	
6	0.32	a	1.16	a	6.39	bcde	3.03	bcd	*	
7	0.26	b	0.96	bcd	5.12	g	1.87	g		****
8	0.14	ef	0.66	e	5.75	efg	2.71	de	****	
9	0.17	cdef	0.88	d	5.57	fg	2.39	ef	****	
10	0.18	cdef	1.08	ab	5.89	def	2.42	ef		****
11	0.16	def	0.47	f	1.79	j	0.79	h	**	****
12	0.16	def	0.47	f	2.38	ij	0.78	h	**	****
13	0.14	ef	0.55	ef	2.94	hi	1.02	h	**	****
14	0.12	f	0.62	ef	3.41	h	2.16	fg	**	****
15	0.13	ef	0.68	e	5.60	fg	3.50	a	**	****
16	0.14	ef	0.50	f	2.87	hi	0.98	h	***	****
17	0.16	def	0.91	cd	6.26	cdef	3.25			****
18	0.17	cdef	0.47	f	2.22	ij	0.69	h	**	***
19	0.22	bcd	1.07	ab	7.11	ab	3.56	a	***	
20	0.21	bcd	0.98	abcd	6.26	cdef	2.90	cd	****	

[z]Symbols indicate the relative extent of internal rot and tipburn damage: * = slight; ** = medium; *** = severe **** = very severe.

Effect of nitrogen source on nutrient uptake. The changes in nitrogen uptake at each growth stage is presented in Fig. 19. Nitrogen uptake by Chinese cabbage increased steeply from May 8 when the heads began to form. Nitrogen uptake was clearly reflected in plant growth and yield. Plants which showed healthy growth from transplanting time until harvest steeply increased nitrogen uptake up to head-formation stage, and afterwards, kept on absorbing a constant amount of nitrogen. However, plants which suffered severely from tipburn decreased its nitrogen uptake steeply after reaching the greatest uptake of nitrogen.

On the other hand, Ca uptake at each growth stage was closely related to the period of NH_4-N application (Fig. 20). This means that Ca uptake was greatly suppressed by the application of NH_4-N. It was already shown that Ca uptake is suppressed by such monovalent cations as NH_4-N and K.

The distribution of Ca in the leaf blade and midrib together with the frequency of tipburn and internal rot is summarized in Table 19. Tipburn symptoms were found in treatments 3, 7, 10, and 11 to 18. In treatments 3, 7, and 10, NH_4-N was applied during head initiation, and in treatments 11 to 18, from the initial growth stage until either the head-formation or harvest time. As is mentioned in the previous section, these facts indicate that the head-formation stage is most sensitive to tipburn.

Regardless of concentration, Ca was lower in plants supplied with NH_4-N throughout the growth stage (Treatment 11 to 14, 16, and 18). Ca content in the outer leaves was 10 to 30 times higher than that in the head leaves. Since Chinese cabbage transpires chiefly from the outer leaves after head formation, and Ca is mainly transported through the transpiration stream; Ca is accumulated in the outer leaf, especially in the leaf blade.

Table 20 shows the distribution of total nitrogen (T-N) both in the leaf blade and midrib of head and outer leaves. T-N content in the leaf blade of head leaves was always higher than that in the midrib. In treatments 4, 7, 8, and 18 where yield losses were great due to NH_4-N application at the 4th WATR, a lot of nitrogen was also accumulated in the head leaves. In general, nitrogen content in the outer leaves of plants with tipburn symptoms, was much lower than that in plants without these symptoms.

In addition, the ratio of T-N content in the leaf blade to that in the midrib correlated well with tipburn frequency (Table 20). The ratio is less than 1 or, at most, a little more than 1 in plants without tipburn symptoms and far more than 1 in plants with symptoms. These facts indicate that further metabolism of the NH_4-N to protein by way of amino acids and amides in the active assimilation sites is retarded due to high NH_4-N supply. Consequently, NH_4-N is accumulated there, causing a more severe inhibition of protein synthesis. Actually, it has been confirmed that a heavy application of NH_4-N is frequently accompanied by a steep increase in both free amino acids and amides, and inversely by a great decrease in protein.

There was close correlation between nitrogen and Ca content in leaves and head dry weight (Table 21). Nitrogen content in the head leaf negatively correlated with head weight. This also indicated that NH_4-N is accumulated in the leaf blade of the head leaves with the tipburn symptom. Both the calcium-nitrogen ratio and Ca content correlated closely with weight. NH_4-N suppressed Ca uptake because of severe root damage or competitive inhibition of Ca uptake, or both. As already described previously, a heavy application of NH_4-N caused its accumulation, thus, resulting in a great decrease in the calcium-nitrogen ratio and then, head weight.

Internal rot symptoms. Even when no tipburn symptoms were found on the outside of leaves, the edges of inner leaves were often rotted. Hereafter, this symptom is referred to as internal rot. Internal rot occurred in almost all treatments except in treatment 7, 10, and 17; so, it is difficult to find any relationship between frequency of internal rot and each treatment. Judged from the effect of each treatment on the extent of internal rot damage, however, internal rot is aggravated by later application of NH_4-N. Ca content of the head leaf, however, did not correlate with internal rot.

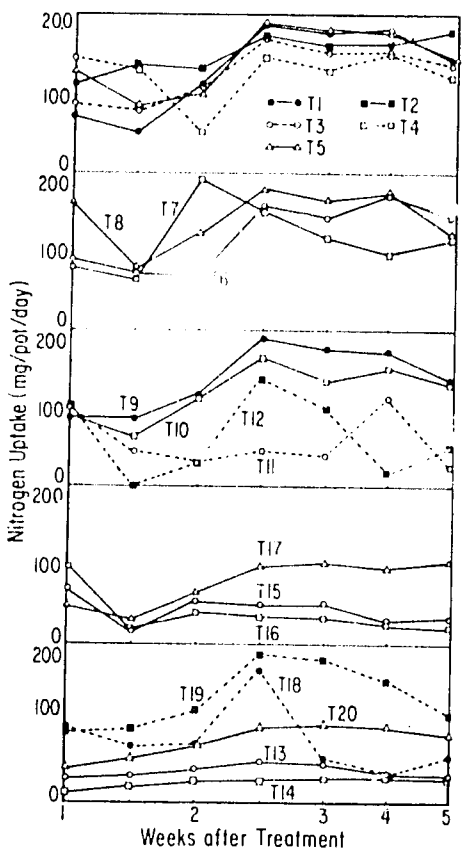


Fig. 19. Change in nitrogen uptake at each growth stage.

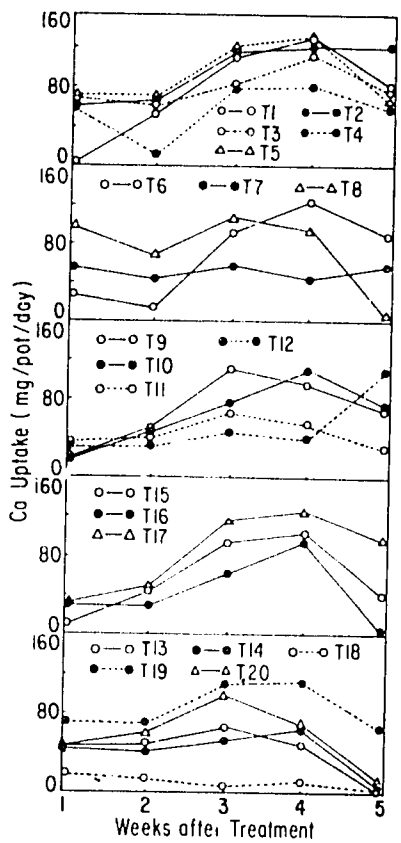


Fig. 20. Change in Ca uptake at each growth period.

Our studies confirmed that internal rot could not be prevented by applying additional Ca, and that it is in part, due to compact heads associated with excessive vegetative growth because of a heavy application of basal nitrogen. Avoiding a high nitrogen rate throughout the growth period can prevent both tipburn and internal rot. Deep plowing, the application of compost or other organic materials, and split application of nitrogen are all effective ways of accomplishing this goal.

It is again confirmed in this experiment that tipburn is not primarily caused by a deficiency of Ca, but rather by ammonia toxicity. However, internal rot occurs even in plants applied with NO_4-N and has absolutely no connection with Ca application. Further studies on this are necessary.

Table 20. Distribution of total nitrogen content in leaves of ASVEG 1.[z]

Treatment	Total Nitrogen (%)				
	head leaf		outer leaf		
	blade	midrib	blade	midrib	blade/midrib ratio
1	3.86 efgh	3.22 cdef	4.01 bcd	4.61 a	0.87
2	4.03 efgh	3.38 cd	4.24 bcd	4.19 abc	1.01
3	4.35 def	3.51 bc	4.47 b	3.91 bc	1.14
4	5.23 ab	3.95 a	4.33 bc	4.13 bc	1.05
5	4.23 defg	4.00 a	4.14 bcd	4.33 ab	0.96
6	4.03 efgh	3.16 cdef	4.14 bcd	4.30 ab	0.96
7	4.82 bcd	3.98 a	4.62 b	3.39 de	1.36
8	4.82 bcd	4.18 a	3.98 bcd	3.81 cd	1.04
9	4.30 def	3.83 ab	4.57 b	3.81 cd	1.20
10	4.37 def	3.55 bc	4.53 b	3.80 cd	1.19
11	4.44 cde	2.85 fg	3.26 ef	2.28 f	1.43
12	4.34 def	2.74 g	3.62 de	2.13 fg	1.70
13	4.15 efg	2.99 defg	2.32 fg	2.01 fg	1.15
14	3.43 h	1.53 j	2.17 h	0.99 g	2.19
15	3.77 fgh	1.97 i	2.15 h	1.10 h	1.95
16	3.65 gh	2.36 h	2.81 fg	1.81 h	1.55
17	4.10 efg	2.95 efg	3.67 cde	3.03 e	1.21
18	5.04 bc	3.97 a	5.59 a	4.02 bc	1.39
19	4.15 efg	3.30 cde	3.70 cde	4.31 ab	0.86
20	5.74 a	4.15 a	3.07 ef	3.30 e	0.88

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

Table 21. Correlation coefficients between leaf nutrient content and head dry weight.[z]

Nutrient Content	Head Dry Weight	
	Fong-Luh	ASVEG 1
T-N in Head leaf blade	−0.445 **	−0.127 ns
Head leaf midrib	−0.246 ns	0.293 ns
Outer leaf blade	−0.137 ns	0.290 ns
Outer leaf midrib	0.494 **	0.648 **
CaO in Head leaf blade	0.049 ns	0.385 *
Head leaf midrib	0.469 **	0.821 **
Outer leaf blade	0.575 **	0.904 **
Outer leaf midrib	0.418 **	0.859 **
Ca/N in Head leaf blade	0.149 ns	0.462 **
Head leaf midrib	0.472 **	0.561 **
Outer leaf blade	0.533 **	0.571 **
Outer leaf midrib	0.209 ns	0.080 ns

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level.

Conclusion

Chinese cabbage tipburn is not caused by calcium deficiency, as is commonly believed, but rather by water stress resulting from root damage caused by ammonia toxicity. Internal rot is also brought about by the excessive application of nitrogen, and is unaffected by calcium levels.

The head-formation stage is the most sensitive period to tipburn; hence, NH_4-N should be avoided at this stage. It should be applied one week after head initiation, however, to obtain high Chinese cabbage yield.

An optimum ratio of ammonia to nitrate is necessary to get maximum yield. At the early stage, NH_4-N application is preferable; however, the ratio of NH_4-N to NO_3-N should be gradually reduced until one week before head formation, after which, NO_3-N must be the sole source of nitrogen.

Management which eliminates excess soil moisture rapidly and decreases nitrogen supply to plants are recommended for summer cultivation of Chinese cabbage. High beds, underground drainage, deep plowing, organic matter, and split application of nitrogen are all effective ways of minimizing both tipburn and internal rot.

Effect of Soil Depth and Suppression of Transpiration from the Outer Leaves of Chinese Cabbage on Tipburn and Internal Rot

Introduction

Our studies showed that Chinese cabbage tipburn is not caused by Ca deficiency, but rather by water stress resulting from root damage by ammonia toxicity. However, it occurs even in plants applied with NO_3-N; so, a different approach to the cause of internal rot and tipburn has to be considered.

In the previous experiment, it was confirmed that Ca/N ratio as well as Ca content in the head leaves highly correlated with the yield and the extent of tipburn damage. This project was, therefore, initiated to examine the effect of soil depth and some countermeasures to suppress Ca accumulation in the outer leaves (where Ca transpiration takes place), accelerate Ca translocation to the inner leaves where internal rot often occurs, and decrease the frequency of tipburn and internal rot.

Materials and Methods

The experiment was conducted in a greenhouse in the late summer of 1984. The split plot design with two replications was adopted, in which the difference in soil depth was chosen for the main plot and the countermeasures to suppress transpiration from the outer leaves, for the sub-plot. The detailed design is given in Table 22.

Table 22. Treatments[z].

Main Plot	Subplot
soil depth	countermeasures to decrease transpiration from outer leaves
1. 7.5 cm	1. No treatment
2. 15.0 cm	2. Compost application (soil and compost ratio = 4:1)
3. 26.0 cm	3. Wrapping outer leaves with aluminum foil after head initiation
	4. Wrapping outer leaves with plastic film after head initiation
	5. Covering plants with a black net after head initiation (50% light intensity)
	6. Wrapping the whole plant with a plastic bag at night

[z]Fertilizers: Treatment 1 = N-N_2O_2-K_2O (1-1-1 g/pot). Treatment 2 to 6 = N-P_2O_5-K_2O (2-2-2.5 g/pot) as basal and 1 g N at head initiation.

A plastic container, $50 \times 35 \times 30$ cm^3, served as a cultivation pot to secure sufficient area round the plant. Soil depths of 7.5, 15, and 24 cm had weights of 16, 32, and 50 kg, respectively. Seedlings were transplanted on August 16, 1984 and harvested on September 26, 1984. The duration time from transplanting to harvest was 41 days.

In treatments 3 and 4, several outer leaves were wrapped either with aluminum foil or plastic film at different times: three leaves on August 31, two leaves on September 8, and two leaves on September 11. At the same time, Chinese cabbage #62 was cultivated outside the greenhouse to determine if covering the outer leaves with rice straw would affect tipburn and internal rot frequency.

Results

Soil depth. Plant growth and damage extent of tipburn and marginal rot on Chinese cabbage are summarized in Table 23. Plant growth was always very poor in 7.5 cm soil depth, regardless of subtreatments. However, with increased soil depth, plant growth was better.

At head-initiation time, all the plants grown in the 7.5 cm depth showed tipburn symptom. Compost application and the black net covering aggravated the tipburn. The symptom developed more severely in the following week. This fact confirms a previous experiment showing that Chinese cabbage was most susceptible to tipburn at the head initiation stage.

The study indicated that soil depth, namely, total soil mass was a very important factor in tipburn development, and that wrapping the outer leaves with either aluminum or transparent plastic film greatly decreased tipburn frequency when a sufficient soil mass was provided.

At harvest, many plants were affected by marginal rot, as well as tipburn. Soil mass slightly affected frequency of marginal rot, but the aluminum foil or plastic film wrapping

Table [illegible]. Plant growth and extent of tipburn and marginal rot damage on Chinese cabbage.[z]

Treatment	Soil Depth (cm)	Date Surveyed: Sept. 8 (head initiation)		Sept. 14 (1 week after head initiation)			Sept. 26 (harvest)		
		growth	tipburn	growth	tipburn	marginal rot	tipburn	marginal rot	remark[y]
1. Check	1. 7.5	2	2	2.5	3	0.5	2	0.5	
	2. 15	2.5	0.5	4.5	0.5	0	0.5	1.0	
	3. 26	2.5	0	4	0	0	0	3	D
2. Compost	1. 7.5	2	2	2.5	4	0.5	3.5	2.5	
	2. 15	2.5	1.5	2.5	4	0	3.5	2.5	
	3. 26	3	0.5	4	0.5	0	1.5	3	S
3. Aluminum foil	1. 7.5	1	1	1.5	2.5	0	3	0	
	2. 15	3	0	4	0	0	0	0.5	D
	3. 26	3	0	5	0	0	0	0	D
4. Plastic film	1. 7.5	2	2	2.5	3	0	3.5	1	
	2. 15	2.5	0	4	0	0	0	0.5	
	3. 26	3	0	4	0	0	0	0	
5. Black net	1. 7.5	1.5	1.5	1.5	2.5	0.5	2	1.5	
	2. 15	2.5	1	2.5	2.5	0	2.5	2	
	3. 26	3	1.5	3.5	1.5	0	1.5	1	
6. Covering at night	1. 7.5	1	0.5	1.5	2	0.5	1	1	
	2. 15	3	0	3.5	0.5	0	0	–	D
	3. 26	2.5	0	4.5	0.5	0	0	1.5	

[z]Numerals indicate the relative extent of plant growth and tipburn and marginal rot damage. The growth and damage increase as the number grows. The numerals of a growth stage cannot be compared with those of other growth stages. [y]D = infected by disease, S = infected by soft-rot.

effectively decreased it. A survey after harvest showed that all the plants suffered severely from internal rot. So, the countermeasure to decrease transpiration from the outer to the inner leaves effectively minimized tipburn, slightly reduced marginal rot, but had absolutely no effect on internal rot.

Table 24 shows the difference in Chinese cabbage yield among treatments. Both outer leaf weight and head weight increased greatly with an increase in soil depth. It indicated that, at least, 45 liters of soil volume is needed for each plant.

Suppressing transpiration. The aluminum foil wrap resulted in a great loss in dry matter production, but the transparent plastic film did not produce any significant yield loss. This suggests that the outer leaves play a key role in dry matter production even after head formation. This was confirmed in a field experiment conducted with the same seedlings at the same time (Table 25). Yield loss was significantly great when rice straw was used to cover the outer leaves after head initiation, but the time of covering did not affect the yield significantly.

After harvest, an internal rot survey revealed that, unlike in the greenhouse trial, no plants suffered from the disease.

A comparison of the two experiments showed that there was a considerable difference in rate of plant growth between them. Plants cultivated in the greenhouse grew much faster,

Table 24. Effect on Chinese cabbage yield of soil depth and countermeasures to decrease transpiration from outer leaves.

Treatment	Outer Leaf Wt (g/plant)	Inner Leaf Wt (g/plant)	Total Wt (g/plant)
Main Plot: Soil Depth			
1. 7.5 cm	404.0 c	213.7 b	617.7 c
2. 15 cm	713.9 b	419.7 a	1133.6 b
3. 26 cm	881.9 a	517.6 a	1399.4 a
LSD (.05)	126.0	105.7	95.7
Subplot: Countermeasures to decrease transpiration from outer leaves			
1. No treatment	769.4 a	512.4 a	1281.8 a
2. Compost	747.6 ab	317.2 ab	1064.8 abc
3. Aluminum foil	524.4 b	268.3 b	792.7 c
4. Plastic film	763.2 ab	421.0 ab	1184.2 a
5. Black net	600.6 ab	254.6 b	855.2 bc
6. Covering at night	594.4 ab	528.4 a	1122.8 ab
LSD (.05)	218.2	205.9	293.4

Table 25. Effect on Chinese cabbage yield of outer leaves covered with rice straw at different growth stages.[z]

Treatment	Total Weight (g/plant)	Head Weight (g/plant)
Main Plot		
1. Check	1101.3 a	646.3 a
2. Covering with rice straw	907.5 b	484.4 b
LSD (.05)	105.7	97.6
Subplot		
1. 20 days BH[y]	1018.8 a	560.0 a
2. 15 days BH	993.8 a	550.0 a
3. 10 days BH	1027.5 a	577.5 a
4. 5 days BH	977.5 a	573.8 a
LSD (.05)	190.6	123.5

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test. [y]Covering outer leaves with rice straw at 20 days before harvest.

especially at the initial growth stage, than those in the field. Generally, pot experiments provide a better environment for plant growth. Thus, vigorous initial growth is frequently associated with marginal and internal rot as well as tipburn. For Chinese cabbage cultivation in summer or in the greenhouse, therefore, water management and basal nitrogen application should be such that vigorous plant growth is avoided.

In the field, tipburn symptom can be seen frequently in the summer. A soil survey of these fields revealed a soil environment different from that in the greenhouse. Farmers have to water the plants frequently, resulting in an alternately overdry and overwet condition that contributes greatly to tipburn and soft rot. So, to avoid tipburn hazard for summer Chinese cabbage cultivation, adequate cultural practices should be followed that avoid vigorous plant growth, excess soil moisture, and undue salt concentration; and increase soil volume and water-holding capacity.

Nutrient uptake. Nutrient contents in the tissues of Chinese cabbage are presented in Table 26. Nitrogen content generally decreased with an increase in soil depth. In the subtreatments, it increased greatly when the whole plant was covered with a black net or the outer leaves with aluminum foil. Compost application and the transparent plastic wrap of outer leaves resulted in a steep decrease in nitrogen content in the outer leaves. Covering the whole plant with plastic sheet at night showed nitrogen content at its lowest in the inner leaf tissue.

Ca content in the tissues, except in the outer leaf blade, decreased with increasing soil depth. In the subtreatments, the night cover resulted in the highest Ca content, followed by nontreatment and netting. Compost application and aluminum foil wrapping resulted in the lowest and the second lowest Ca content. On the other hand, potassium (K) content did not show any correlation with soil depth. In the subtreatments, K apparently accumulated in the tissues of badly growing plants. A similar trend was observed for N and Ca contents in the Chinese cabbage tissues.

In this experiment, all the plants suffered from internal rot regardless of the treatment. The nitrogen-to-calcium ratio in the outer leaves was nearly 1 while that in the inner leaves was extremely high, and nitrogen concentration in the inner leaf blade was 20 times as much

Table 26. Effect on nutrient content in Chinese cabbage of soil depth and countermeasures to decrease transpiration from outer leaves.[z]

Treatment	Total-N (%)				Ca (%)				K (%)			
	OB	OM	IB	IM	OB	OM	IB	IM	OB	OM	IB	IM
Main Plot:												
Soil Depth												
1. 7.5 cm	3.67a	2.75a	4.72a	3.54a	3.22b	3.00a	0.29a	1.23a	1.82b	5.71a	3.17a	3.45a
2. 15 cm	3.25c	2.35c	4.17b	3.14b	3.31b	2.87b	0.22c	1.01b	1.98b	5.66a	3.02a	3.21b
3. 24 cm	3.46b	2.49b	3.95c	2.81c	3.44a	2.69c	0.25b	0.97b	2.19a	6.27a	2.74b	3.35ab
LSD (0.05)	0.05	0.06	0.03	0.05	0.10	0.08	0.00	0.06	0.19	0.67	0.23	0.16
Subplot												
1. No treatment	3.57c	2.75c	3.93e	2.79e	3.88a	3.00a	0.24b	1.05c	1.88bc	5.34c	2.83b	3.52a
2. Compost	2.38f	1.78f	4.36c	2.85d	2.98c	2.57d	0.19d	0.93d	2.15b	6.07b	3.17a	3.28ab
3. Aluminum foil	4.03a	2.84b	4.76a	4.42a	3.60b	2.76c	0.22c	0.67e	2.58a	6.80a	2.92b	3.10b
4. Plastic film	3.42e	2.37e	4.30d	2.93c	2.99c	2.89b	0.22c	1.30a	2.08bc	5.25c	2.88b	3.37ab
5. Black net	3.85b	2.91a	4.59b	3.36b	3.63b	2.88b	0.24b	1.19b	1.85c	6.31b	3.17a	3.30ab
6. Covering at night	3.51d	2.54d	3.73f	2.62f	2.85d	3.01a	0.41a	1.28a	1.45d	5.52c	2.89b	3.48a
LSD (.05)	0.02	0.06	0.02	0.04	0.08	0.10	0.01	0.04	0.26	0.45	0.15	0.29

[z]OB = outer leaf blade; OM = outer leaf midrib; IB = inner leaf blade; IM = inner leaf midrib. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

as Ca concentration (Table 27). A similar trend could be seen in the relation of Ca to K; therefore, the suppression of Ca absorption and its translocation to the inner leaves after head formation stage is a main factor for Chinese cabbage internal rot.

Conclusion

This experiment confirms the finding that the head initiation stage is the most susceptible to tipburn. It also shows that soil depth and total soil volume are very important factors in avoiding tipburn hazard, and that at least, 45 liters of soil volume should be provided each plant.

The countermeasures to decrease transpiration from the outer leaves were effective against tipburn, slightly effective against marginal rot, and absolutely not effective against internal rot. Outer leaves covered by either aluminum foil or rice straw resulted in a great decrease in head and total weight. This suggests that outer leaves play a key role in dry matter production after the head formation stage.

A vigorous initial growth was frequently associated with marginal and internal rot, as well as tipburn. For Chinese cabbage cultivation in summer or in the greenhouse, therefore, water management and basal nitrogen application should be such that vigorous plant growth is avoided. To avoid tipburn and internal rot in summer, an adequate cultural practice to meet the following requirements should be taken:

1. Enough soil volume for each plant.
2. Increased water-holding capacity of the cultivated soil.
3. No vigorous plant growth.
4. No excess soil moisture.
5. No salt concentration in the soil due to fertilizer application.

Table 27. Difference in nutrient distribution ratio of Chinese cabbage.[z]

Treatment	Ca/N					Ca/K				
	OB	OM	IB	IM	total	OB	OM	IB	IM	total
Main Plot:										
Soil Depth										
1. 7.5 cm	0.96b	1.19a	0.061b	0.41a	0.729b	1.97a	0.58a	0.091a	0.38a	0.788a
2. 15 cm	1.02a	1.15b	0.056c	0.41a	0.755a	1.69b	0.57a	0.074b	0.36a	0.774a
3. 24 cm	1.03a	1.05c	0.065a	0.40a	0.719c	1.70b	0.50b	0.092a	0.33b	0.757b
LSD (.05)	0.02	0.03	0.000	0.01	0.008	0.07	0.04	0.005	0.02	0.016
Subplot										
1. No treatment	1.09b	1.07c	0.060b	0.45c	0.694d	2.07ab	0.63a	0.084b	0.36bc	0.809a
2. Compost	1.28a	1.51a	0.045d	0.39d	0.937a	1.42d	0.53b	0.062d	0.33c	0.719b
3. Aluminum foil	0.90d	0.95d	0.046d	0.19e	0.681d	1.42d	0.45c	0.074c	0.25d	0.728b
4. Plastic film	0.96c	1.19b	0.051c	0.47b	0.746b	1.66c	0.61a	0.076c	0.40a	0.831a
5. Black net	0.94c	0.97d	0.053c	0.38d	0.731c	1.98b	0.52b	0.078bc	0.38ab	0.833a
6. Covering at night	0.85e	1.08c	0.108a	0.54a	0.615e	2.19a	0.59a	0.139a	0.41a	0.716b
LSD (.05)	0.02	0.05	0.003	0.02	0.014	0.15	0.05	0.006	0.03	0.047

[z]OM = outer blade, OM = outer midrib, IB = inner blade; IM = inner midrib, total = total plant. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Effect of Covering and Foliar Spray on Chinese Cabbage Tipburn and Internal Rot

Introduction

Our studies showed that Chinese cabbage tipburn resulted from serious root damage caused by ammonium toxicity, consequently inhibiting Ca uptake and translocation. Wrapping

outer leaves with either aluminum foil or transparent plastic film resulted in a significant decrease of tipburn, but not on internal rot. The application of compost and covering the whole plant with black net aggravated tipburn.

This project aimed to find out if covering outer leaves after head formation and foliar-spraying of calcium on Chinese cabbage had any effect on tipburn and internal rot.

Materials and Methods

The experiment was conducted in field no. 28 in autumn 1984. The split plot design was used with the cultivars as the main plot, and the foliar spray and covering treatments as the subplot (Table 28). Seedlings of #62 (December 30) and Fong-Luh (November 2) were transplanted to a plastic container, $50 \times 35 \times 30$ cm^3 in size with a soil depth of 20 cm, and harvested on December 11 and December 14, respectively.

Results

Results are summarized in Tables 29 and 30. All the treatments, except split application of liquid nitrogen, showed symptoms of either marginal or internal rot, regardless of cultivar. Foliar spraying with Ca did not cure marginal rot; in fact, $CaCl_2$ resulted in serious damage by this disease. The citrate spray increased the yield and minimized marginal rot, but Ca-citrate did not work well.

Covering the outer leaves before head formation gave higher yields than the other cover treatments and decreased marginal rot frequency. Covering after head formation always decreased head weight greatly and aggravated marginal rot. This finding confirmed a previous experiment on tipburn. However, covering after head formation until harvest resulted not only in decreasing head weight greatly, but also in aggravating tipburn. Outer leaves play a key role in carbohydrate production after head formation in Chinese cabbage; and if they are covered, the supply of carbohydrate to the inner leaves from the outer leaves is impeded; thus, C/N of the plant tissue becomes narrow and the leaf blades in the head easily damaged by marginal or internal rot.

These facts show that suppressing vigorous plant growth before and at head formation stage minimizes tipburn and marginal rot effectively. These facts are also confirmed in treatments 1 and 2, split application of liquid NH_4-N or NO_3-N. Split application minimizes nitrogen intake by the plants and avoids initial vigorous growth. In these treatments, only 0.25 g of nitrogen was applied each time, which kept plant growth constant. Consequently, the plants produced heavy heads with absolutely no symptoms.

Table 28. Treatments.

Main plot: Varieties, Fong-Luh & ASVEG 1 (#62)				
Subplot NO.	N Fertilizer	Foliar Spray	Covering[z] before	Covering[z] after
1.	Liquid, NH_4-N	–	–	–
2.	Liquid, NO_3-N	–	–	–
3.	Solid, NH_4-N	–	–	–
4.	"	–	+	–
5.	"	–	–	+
6.	"	Ca-citrate[y]	+	+
7.	"	Ca-citrate	–	+
8.	"	Ca-citrate[x]	–	+
9.	"	Ca-citrate	–	–
10.	"	$CaCl_2$	–	–
11.	"	Citrate	–	–
12.	"	H_2O	–	–

[z]Before and after head initiation; – = no covering, + = covering of outer leaves with a black plastic sheet.
[y]50 ml/pot of Ca-citrate at a concentration of 0.0005 M is sprayed twice a week from one week after transplanting (WAT). [x]This foliar spray begins after covering the outer leaf.

Table 29. Effect of covering and foliar spray on Chinese cabbage yield.[z]

Treatment	Total Weight	Head Weight
Main Plot: Cultivars	(g/plant)	(g/plant)
1. Fong-Luh	1412.1a	648.9a
2. #62	1165.8a	688.1a
LSD (.05)	1170.0	645.6
Subplot: Countermeasures to Avoid Internal Rot		
1. Liquid NH_4-N	1440.0ab	901.7ab
2. Liquid NO_3-N	1655.0a	980.6a
3. Solid NH_4-N (check)	1465.0ab	660.0cdef
4. Covering BHF[y]	1425.0ab	675.1cde
5. Covering AHF[x]	947.5c	462.1g
6. Covering B & AHF	1072.5c	550.6defg
7. Covering AHF + Ca-cit FS	980.0c	491.0efg
8. Covering AHF + Ca-cit FS	1055.0c	472.1fg
9. Ca-cit FS[w]	1442.5ab	723.7bcd
10. $CaCl_2$ FS	1352.5b	618.7cdefg
11. Citrate FS	1432.5ab	805.9abc
12. Water FS	1200.0bc	674.3cde
LSD (.05)	252.0	177.9

[z]Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test. [y]Before head formation. [x]After head formation. [w]Ca-citrate foliar spray.

Table 30. Effect of covering and foliar spray on Chinese cabbage tipburn and internal rot.[z]

Treatment	Fong-Luh			ASVEG 1	
	head weight	marginal rot	internal rot	head weight	internal rot
1. Liquid NH_4-N	939.0ab			864.4a	
2. Liquid NO_3-N	1049.0a			912.2a	
3. Solid NH_4-N	656.5bc	***		675.4ab	***
4. Covering BHF[y]	631.0bc	*	*	719.3ab	**
5. Covering AHF[x]	359.0c	****		565.3b	**
6. Covering BAHF[w]	528.0bc	***	*	573.2b	**
7. Covering AHF + Ca-cit FS[v]	448.5bc	*****		533.4b	***
8. Covering AHF + Ca-cit FS	468.5bc	****		475.7b	***
9. Ca-cit FS	646.5bc	*****		860.9ab	**
10. $CaCl_2$ FS	686.5b	******		550.9b	****
11. Citrate	801.5ab		**	810.3ab	**
12. Water FS	572.5bc	*		776.1ab	**
LSD (.05)	251.6			251.6	

[z]Symbols indicate the relative extent of marginal rot and internal rot damage: * = Very slight; ** Slight; ***, **** = Medium, ***** = Severe; ****** = Very severe. Means within a column followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test. [y]Before head formation. [x]After head formation. [w]Before and after head formation. [v]Ca-citrate foliar spray.

Conclusion

Foliar spray of Ca-citrate and $CaCl_2$ did not cure marginal and internal rot, but citrate spray increased yield and decreased the incidence of these diseases. Covering the outer leaves before head formation gave high yield and decreased the frequency of marginal rot. The split application of liquid nitrogen gave the heaviest heads without any tipburn symptom. This study showed the importance of avoiding vigorous initial plant growth brought about by high nitrogen rate and water application.

Tomato and Chinese Cabbage Cultivation on a High Bed

Introduction

Tomato needs high light intensity and a dry and cool climate for growth. It is extremely susceptible to various kinds of diseases under hot and humid conditions. Flooding is also a major constraint in summer tomato production. It was confirmed that a 100 cm raised bed with a vinyl roof could save tremendous amounts of water and fertilizer, and minimize disease infection and flood damage in summer vegetables. This project was designed to assess the advantages and disadvantages of cultivating tomato and Chinese cabbage on higher than normal beds in the rainy season.

Materials and Methods

Seedlings of tomato, CI 1131-0-0-43-8-1, was transplanted on 70 cm raised bed on July 5, 1984, and harvested seven times until December 19, 1984. Each 1 × 10 m bed was planted to two rows of tomato, with spaces of 50 cm between plants and 50 cm between rows.

Fertilization is summarized in Table 31. For the first week after transplanting, each seedling on the high bed received 300 ml of water everyday. Afterwards the plant was not watered for one month until the fruit-enlarging stage of the first harvest. Then, each plant received one liter of water at this stage of every harvest. In the low-bed cultivation, ordinary furrow irrigation was conducted whenever necessary.

In the Chinese cabbage trial, seedlings of #62 were transplanted on April 16, 1984 and harvested on June 5, 1984. Other experimental conditions were the same as in the tomato trial.

Results

Tomato. Results are summarized in Table 32. Plants on the low bed had more flowers and more fruits during the first harvest. By the second harvest, however, plants on the high bed were producing more and bigger fruits. Fruit number and weight on the high bed were, respectively, four times and seven times more than those on the low bed, by the third harvest. Almost all the plants on the low bed died because of serious infections from such diseases as bacterial wilt and southern blight. Plants grown on the high bed continued to flower and set fruit even after the 7th harvest.

In a similar experiment which was conducted last autumn, it was confirmed that plants on the high bed had more fruits, though they were generally smaller. Plants grown on the low bed still produced the greatest total fruit weight. But the experiment was conducted in the dry season and water was not given until the plants wilted. This brought about severe retardation of flowering and fruiting thereafter.

In the present experiment, however, plants were watered sufficiently at the most sensitive stage for flowering and fruit setting. Therefore, plants yielded nearly four times more on the high bed than on the low bed. Thus, the 70 cm raised bed with a clear plastic roof was a very effective way of getting rid of tomato diseases, such as southern blight and bacteria wilt, in the summer cultivation.

Table 31. Fertilization of tomato cultivated on high and low beds.

Fertilizer	High Bed (kg/ha)			Low Bed (kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Basal	30	30	30	60	100	60
Top (1 MAT)[z]	20		20	60		60
Top (2 MAT)	20		20	60		60
Total	70	30	70	180	100	180

[z]MAT = months after transplanting.

Although the high bed was greatly beneficial to summer tomato, it was more costly and needed more labor than the low bed. So, a more practical method for field application was tested. After carefully examining the soil conditions of both beds, some observations were made on two important factors. There was excess soil moisture in the low bed due to heavy rain, and watering in the high bed was done at the base of plants (downward water movement) but that in the low bed was furrow-irrigated (upward water movement).

In the low bed during heavy rain, excess soil moisture promoted bacterial activity and decreasd root activity. In addition, the raindrops hit the bed surface and soil colloids splashed on the leaves where more bacterial infection was initiated. Furrow irrigation carried pathogens to the vicinity of the plant roots, as well as to the bed surface, where they attack the stems in contact with the soil.

To avoid bacterial infection, rain splashing must first be halted through mulching, netting, and roofing. Since infection through the roots seems to be limited, the seedling medium should next be sterilized and the seedlings transplanted with the medium. Furthermore, the seedling with the medium must be kept separate from the surrounding bed soil.

The following seedling preparation and transplanting method were tested to replace high bed cultivation and confirmed its effectiveness in minimizing disease infection to tomato plants.

- Prepare plastic bags 10 cm in diameter and 12 to 15 cm long.
- Pack into this bag the sterilized seedling medium composed of soil, compost, and peat or soil, smoked rice husk, and peat at a ratio of 3:1:0.5.
- Before transplanting the seedlings to the field, cut off the bottom of the plastic bag.
- When transplanting to the bed, leave 5 to 7 cm of the plastic bag above the bed surface. Thus the soil around the plant stays dry even in heavy rain; and the stem close to the soil is kept off the disease germs.

Chinese cabbage. Results are summarized in Table 33. Head weight of Chinese cabbage on the high bed was significantly lower than that on the low bed. This is because water supply

Table 32. Tomato yield on high and low beds.

	High Bed		Low Bed	
	fruit no. (per 40 plants)	fruit weight (kg/40 plants)	fruit no. (per 40 plants)	fruit weight (kg/40 plants)
1st harvest	727	20.00	1411	30.85
2nd "	763	26.56	434	7.47
3rd "	2066	62.10	542	8.90
4th "	847	24.80	---	---
5th "	272	7.89	---	---
6th "	829	15.00	---	---
7th "	1582	27.80	---	---
Total per 40 plants	7086	184.15	2387	48.22
Average fruit No. per plant	177		60	
Average fruit wt (kg/plant)		4.60		1.21
Yield (t/ha)		76.67		20.17

Table 33. Chinese cabbage yield on high and low beds.[z]

	Total Weight (g/plant)	Head Weight (g/plant)	No. of Plants Harvested (harvest/total)	Soft Rot Infection (infected/total)
High bed	1033.8a	516.5b	39/40	0/14
Low bed	1161.0a	740.0a	32/40	21/40
LSD (.05)	153.0	99.3		

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

was strictly limited throughout the growth period. At first a couple of days after transplanting, 300 ml of water was applied to each plant grown on the high bed everyday: but afterward no water was given until a sign of severe wilting was evident. So, some plants suffered from internal rot at harvest.

More then 50% of the plants on the low bed were damaged severely by soft rot at harvest, and the infection rate increased steeply as the growth stage advanced. On the other hand, the plants on the high bed showed no signs of bacterial soft-rot infection.

Conclusion

Raised beds 70 cm high with a clear plastic roof effectively minimized southern blight and bacterial wilt in the summer cultivation of tomato. The high bed also dramatically decreased soft rot infection in summer Chinese cabbage. Tomato fruit weight on the high bed was four times more than that on the low bed. It was also confirmed that the cultural practice using plastic bags 12 to 15 cm long as containers for transplanted seedlings exerted a similar effect as the high-bed cultivation.

Characterizing the Major Soil Groups in the Tropics according to Their Yield Potential

Introduction

It is well known that different soils produce totally different crop yields even when the crops are cultivated under the same management. Soybean cultivars screened on volcanic ash soils reportedly showed more tolerance to phosphorus deficiency and gave higher yields than those screened on alluvial soils. These facts indicate that both tolerance and high-yielding abilities are dependent on soil conditions.

Breeders are often confronted with this difficulty of evaluating cultivars tolerant to nutrient deficiencies and suitable for high yield. It is, therefore, urgent to identify the main limitations to crop production of the major soil groups in the tropics and to characterize them according to their yield potential. This project aimed to develop a simple and practical method to evaluate and characterize tropical soils according to their yield potential.

Materials and Methods

Titration curve. Soil samples were collected from 18 different locations throughout Taiwan. Each soil was titrated with HNO_3 and NaOH in the range of pH 3 to 10. Titration was repeated three or four times on the same soil in the different concentrations of electrolyte ($NaNO_3$) in order to determine its zero point of charge (ZPC). Based on the difference in the shape of the titration curve and the pH value corresponding to ZPC, six soils were chosen to represent the major Taiwan soil groups.

P adsorption. Two grams each of air-dried soil samples were weighed and placed into a 50-ml polyethylene centrifuge tube, and 25 ml of P solution containing 0.1 N HNO_3 or 0.1 N NaOH to bring the equilibrium pH to the desired values was added to it. The concentration of the P solution ranged from 1 to 200 ppm. This P solution also contained $NaNO_3$ corresponding to 0.01 M. The mixture of the soil and P solution was shaken gently for 24 hr at room temperature. After the shaking, the suspension pH was measured and centrifuged. The supernatant was kept for analysis. The Olsen reagent was added to the remaining soil, shaken for 30 min, and then centrifuged. The supernatant was supplied for the analysis of Olsen-extractable P.

Results

Titration curves for AVRDC and Yi-Chi soils are given in Figs. 21 and 22, respectively. There is a great difference in the shape of titration curves between the two soils. This reflects the difference in surface charge density and soil components involved in surface reactions. Therefore, soils with similar titration curves may show similar responses to fertilizer, and hence may produce similar yields. Thus, acid and alkalimetric titration curves of soils can be used to characterize soils.

Six soils with totally different titration curves were chosen to represent the major Taiwan soils and their reactions to fertilizers examined. In this trial phosphate was chosen as the representative fertilizer, because it is one of three major nutrients essential to all plants.

P adsorption by AVRDC soil is presented in Fig. 23. P adsorption is governed by two factors: initial P concentration and pH. With increased pH, P adsorption decreased steeply; in other words, the number of positive charges on the soil surface affected the amount of P adsorbed greatly. This fact also indicated that the characterization of soils on the basis of the titration curve is very useful. P adsorption by the Yi-Chi soil was very similar to that of the AVRDC soil; however, the magnitude of initial linear part and total P adsorption was much greater in the former than in the latter (Fig. 24). This means that there is a great difference in P adsorption among soils. The initial linear part corresponds to the number of positive charges on the surface.

Next, the Langmuir adsorption maximun of P was calculated (Table 34). The adsorption maximum (Xm) decreased steeply with an increase in pH in all the soils tested. There was also a considerable difference in the adsorption maximum among the soils; that of Yi-Chi soil was 3.5 times as much as that of AVRDC soil. As seen in the titration curves, the surface charge density of Yi-Chi soil was much greater than that of AVRDC soil; hence, Xm also reflected the surface charge density of the soils.

When phosphorus fertilizer was applied, the amount available to the crops was totally different for different soils or for the same soils, but with different pH. The Yi-Chi soil needed four to five times more of phosphorus than AVRDC soil to supply the same amount of available phosphate to the crops. So, if a screening of cultivars tolerant to phosphate deficiency is conducted on both soils under the same conditions, the cultivars screened on Yi-Chi soil must be more tolerant to P deficiency, but may become more susceptible to an overdose of

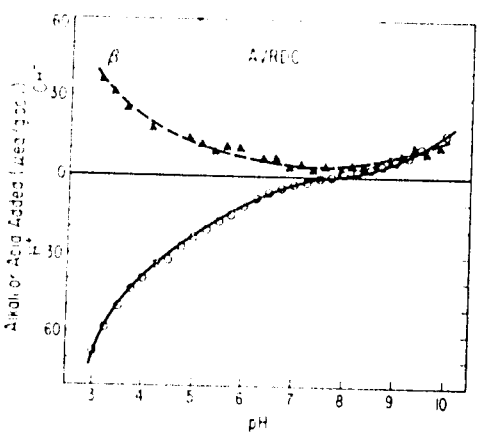


Fig. 21. Titration curve and buffer intensity of soil in 0.1 M $NaNO_3$($\beta = \Delta C_B/\Delta pH$, amount of OH^- or H^+ added per unit pH changed).

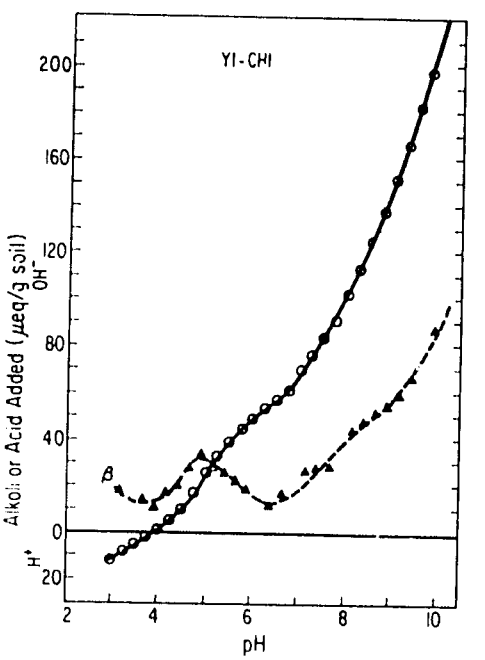


Fig. 22. Titration curve and buffer intensity of soil in 0.0 M $NaNO_3$($\beta = \Delta C_B/\Delta pH$, amount of OH^- or H^+ added per unit pH changed).

phosphate. Thus, this technique is very useful for the characterization of the soils, and hence, applicable to the screening of cultivars tolerant to various nutrient deficiencies.

Although Xm is a good index for determining adequate phosphate fertilization and classifying soils according to their yield potential, it is time-consuming and laborious. So, a search for a much simpler relationship between P adsorption of the soils and various factors affecting it was conducted.

By using multiple regression analysis, various kinds of models were tested, and finally, a simple equation that fitted each experimental point very well (n = 75) was found: Log(P adsorbed) = A + B*log(initial or equilibrium P concentration). This equation does not include pH; so, the amount of P adsorbed by the soils can be decided only by the P concentration. Results are summarized in Tables 35 and 36. The slope of the equation reflects surface charge density and kinds of charging sites; therefore, it can also be used for soil classification.

The last column of Table 36 shows the equilibrium P concentration at which 1 ug P/g soil is adsorbed. Yi-Chi soil gave the lowest value, followed by Lin-Beng, and then by Fong-Shan soils. In Yi-Chi soil, therefore, the equilibrium P concentration is much lower than that in AVRDC soil when the same amount of phosphate is applied to both soils. Thus, we can easily estimate the amount of P adsorbed by various kinds of soils and also classify the soils in terms of the difference in the slope of the first equation or equilibrium P concentration at X = 1 in the second equation.

Finally, this theory was extended to the evaluation of available phosphate for crops. In the previous experiment, it was confirmed that Olsen-extractable P was an excellent index for determining P available to crops in a wide range of soil types. Fig. 25 and Table 37 show

Table 34. Adsorption maximum (Xm) of the soils calculated by Langmuir equation.

Equilibrium pH	Xm (μg P/g Soil)					
	AVRDC	Fong-Shan	Kaohsiung	Lin-Beng	Tung-Ho	Yi-Chi
4	399	452	---	542	714	1448
5	371	235	377	224	406	1231
6	209	224	293	352	404	1039
7	200	210	223	294	314	994
8	255	194	363	252	331	984

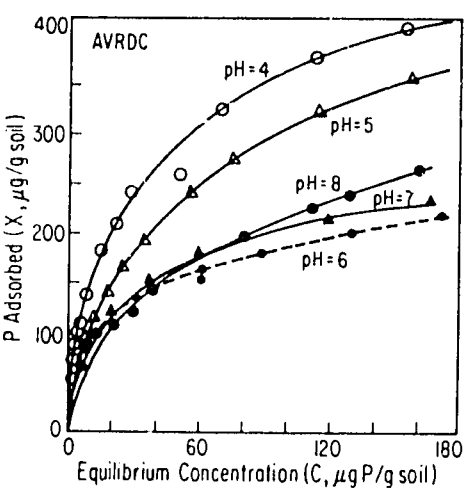


Fig. 23. Langmuir plots of P adsorption at ph 4 through 8.

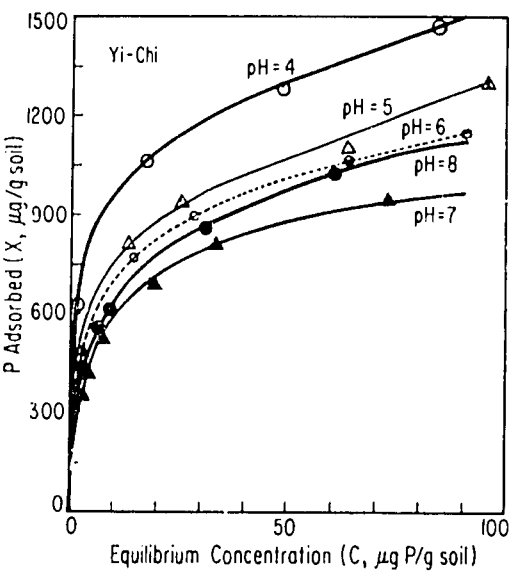


Fig. 24. Langmuir plots of P adsorption at pH 4 through 8.

the relation between Olsen-extractable P and fraction of adsorption (0 = X/Xm) at pH 5 and 7. A close correlation can be found between them. So, available P, Xm, and initial or equilibrium P concentration are easily interchangeable.

Table 35. Relationship between P adsorption (X, μg P/g soil) and Initial P concentrations added (C_i, μg P/ml)

Soil	Regression Equation	Correlation Coefficient	Initial P Conc. at X = 1
AVRDC	$\log X = 1.0839 + 0.6674 \log C_i$	r = 0.9672	0.0238
Fong-Shan	$\log X = 1.2127 + 0.6106 \log C_i$	r = 0.9667	0.0103
Kaohsiung	$\log X = 0.8756 + 0.7692 \log C_i$	r = 0.9712	0.0727
Lin-Beng	$\log X = 1.2511 + 0.6464 \log C_i$	r = 0.9552	0.0116
Tung-Ho	$\log X = 1.0184 + 0.7711 \log C_i$	r = 0.9612	0.0478
Yi-Chi	$\log X = 1.1261 + 0.9232 \log C_i$	r = 0.9843	0.0603

Table 36. Relationship between P adsorption (X, μg P/g soil) and equilibrium P concentration (C_e, μg P/m)

Soil	Regression Equation	Correlation Coefficient	Equilibrium P Conc. at X = 1
AVRDC	$\log X = 1.3985 + 0.5347 \log C_e$	r = 0.9449	2.42×10^{-3}
Fong-Shan	$\log X = 1.6193 + 0.4167 \log C_e$	r = 0.9455	1.30×10^{-4}
Kaohsiung	$\log X = 1.1029 + 0.6923 \log C_e$	r = 0.9546	2.55×10^{-2}
Lin-Beng	$\log X = 1.7548 + 0.4155 \log C_e$	r = 0.9157	5.98×10^{-5}
Tung-Ho	$\log X = 1.4246 + 0.6068 \log C_e$	r = 0.9060	4.49×10^{-3}
Yi-Chi	$\log X = 2.4137 + 0.3333 \log C_e$	r = 0.7971	7.33×10^{-3}

Table 37. Correlation coefficients between Olsen-extractable phosphorus and fraction of adsorption (X/Xm, P adsorbed/adsorption maximum).

Equilibrium pH	Soil					
	AVRDC	Fong-Shan	Kaohsiung	Lin-Beng	Tung-Ho	Yi-Chi
4	0.9908	0.9910	–	0.9565	0.9911	0.9933
5	0.9982	0.9897	0.9936	0.9785	0.9799	0.9987
6	0.9812	0.9895	0.9909	0.9848	0.9700	0.9903
7	0.9899	0.9673	0.9683	0.9916	0.9827	0.9962
8	0.9835	0.9736	0.9793	0.9373	0.9821	0.9894

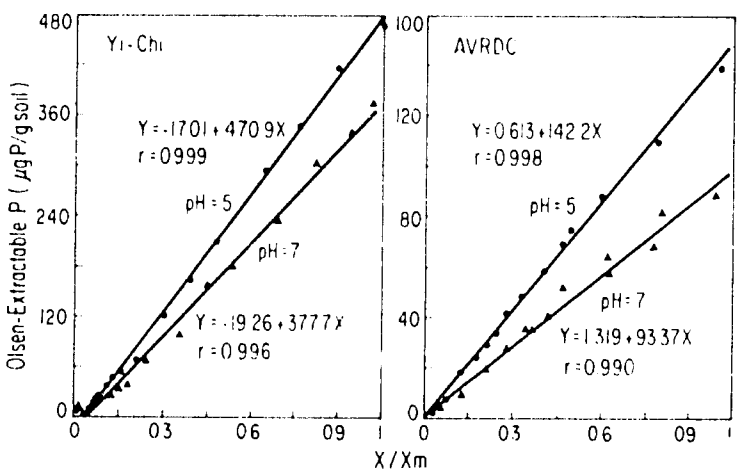


Fig. 25.
Relation between Olsen-extractable phosphorus and fraction of adsorption (X/Xm) at pH 5 and 7.

Conclusion

It was confirmed that acid and alkalimetric titration curves of soils could be used for the characterization of tropical soils according to their yield potential. There was a great difference in P adsorption maximum (Xm) among the soils tested, indicating that the amount of available phosphate to crops was totally different among the soils when the same amount of phosphorus fertilizer was applied.

This technique is very useful for the characterization of soils and is applicable to screening of cultivars tolerant to various nutrient deficiency. To simplify the technique, the following equation is proposed to characterize tropical soils and to determine the amount of P adsorbed: Log(P adsorbed) = A + B*log(initial or equilibrium P concentration). The amount of P adsorbed by various kinds of soils can easily be estimated, and the soils classified in terms of difference in the slope or equilibrium P concentration at X = 1 in the equation.

A close correlation was also found between Olsen-extractable P and fraction of adsorption (0 = X/Xm). So, available P, Xm, and initial or equilibrium P concentration are easily interchangeable.

Effect of pH, EC, and Nutrient Status of AVRDC Soil on Crop Yield

Introduction

To determine optimum soil conditions for better legume and vegetable growth, a new project was started this year. Sulphur powder and peat were applied to the experimental plots in the field in order to change the soil pH and other chemical properties. Crops were cultivated simultaneously on three to four different locations in our field under the same conditions. The locations chosen had a different crop cultivation management; therefore, the effect of soil physical properties on crop yield would be evaluated. Experiments on physical properties are still ongoing, and the chemical analysis of soils and plant tissues has not been completed yet. So, only the results of the soybean trial are presented here.

Materials and Methods

Sulphur powder and peat were scattered homogenously on the soil surface and then rototilled. The amounts of sulphur and peat required to bring the soil pH to desired values were determined by a laboratory test.

Results

Correlation coefficients between yield components and soil nutrients after soybean cultivation are given in Tables 38 and 39 for AGS129 and Kaohsiung No. 8 (KS8), respectively. Soil pH was highly correlated with soybean yield, and the electric conductivity (EC) values were negatively correlated with yield, regardless of cultivar. The NH_4-N content in the soil also had a negative correlation with yield after cultivation. The relationship is plotted in Figs. 26 and 27.

Over a range of soil pH, the yield of AGS129 and KS8 increased by 0.5 and 0.4 t/ha, respectively, for every unit increase in pH value. The quadratic equation showed a best fit for each experimental point with regards to EC; so, the optimum EC value of soils for soybean could be estimated at 0.135.

Although a negative correlation existed between mineral nitrogen concentration and yield, this relation seemed to be meaningless. Experimental points can be separated distinctly into two groups: high yield group and low yield group. The former had no correlation with

yield, and the latter increased yield slightly with increased nitrogen concentration. Thus, soil pH and EC influenced soybean yield greatly, but nitrogen concentration in the soil after harvest did not show any clear correlation with yield.

In an ordinary fertilizer trial, the effect of fertilizer application on crop yield, especially on legume yield, is not very clear. In order to find the optimum soil condition for the maximum

Table 38. Correlation coefficients between soil chemical properties and yield of soybean cultivar AGS129.

	Correlation Coefficients[z]							
	NH_4-N	NO_3-N	pH	EC	Totaln[y]	Totdw[x]	100wt[w]	Yield
NH_4-N	1.0000	-0.0564	-0.5047	0.3068	0.9101	0.0730	-0.4432	-0.4092
	**	NS	**	NS	**	NS	*	*
NO_3-N	-0.0564	1.0000	0.1077	-0.2156	0.3624	0.3431	0.2433	0.3185
	NS	**	NS	NS	*	NS	NS	NS
pH	-0.5047	0.1077	1.0000	-0.6897	-0.4264	0.3648	0.7178	0.8298
	**	NS	**	**	*	*	**	**
EC	0.3068	-0.2156	-0.6897	1.0000	0.1969	-0.5129	-0.5731	-0.6079
	NS	NS	**	**	NS	**	**	**
Totaln[y]	0.9101	0.3624	-0.4264	0.1969	1.0000	0.2105	-0.3127	-0.2498
	**	*	*	NS	**	NS	NS	NS
Totdw[x]	0.0730	0.3431	0.3648	-0.5129	0.2105	1.0000	0.4961	0.5426
	NS	NS	*	**	NS	**	**	**
Plant height	0.0258	0.3294	0.4477	-0.5518	0.1608	0.7429	0.3265	0.6736
	NS	NS	*	**	NS	**	NS	**
Sed/T[v]	-0.3808	0.2809	0.6444	-0.3303	-0.2389	0.4880	0.6745	0.6089
	*	NS	**	NS	NS	**	**	**
Seed No./pod	-0.1933	0.1399	0.1797	0.0526	-0.1224	0.3329	0.2643	0.3513
	NS	NS	NS	NS	NS	NS	NS	NS
Seed wt	-0.2967	0.2730	0.5157	-0.5974	-0.1637	0.6756	0.3065	0.5694
	NS	NS	**	**	NS	**	NS	**
100wt[w]	-0.4432	0.2433	0.7178	-0.5731	-0.3127	0.4961	1.0000	0.7171
	*	NS	**	**	NS	**	**	**
Yield	-0.4092	0.3185	0.8298	-0.6079	-0.2498	0.5426	0.7171	1.0000
	*	NS	**	**	NS	**	**	**

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level. [y]Totaln = Total leaf number. [x]Totdw = Total dry weight. [w]100wt = 100-seed weight. [v]Sed/T = Ratio of seed wt to total dry wt.

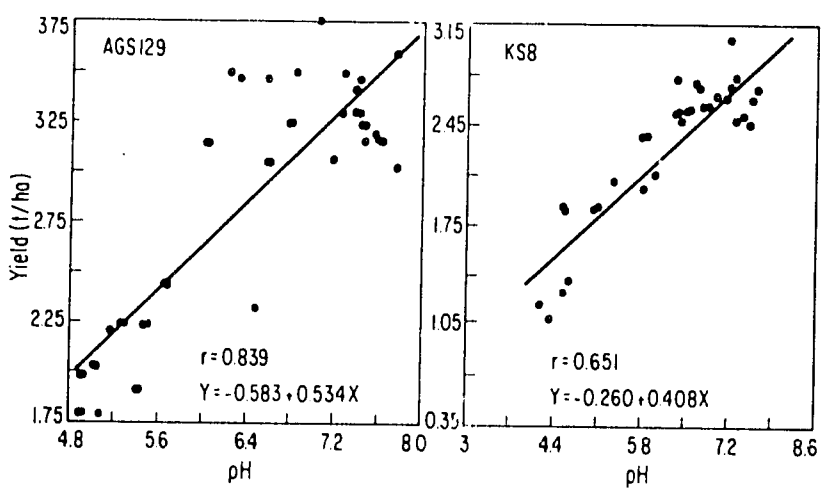


Fig. 26. Effect of soil pH on yield of GS129 and KS8.

yield of crops, we have traced the relationship between soil chemical properties and yield of AVRDC mandate crops. Here is an example on mungbean.

The effect of soil pH, EC, and nutrient status on mungbean yield are plotted in Figs. 28 to 33. There was absolutely no correlation between soil chemical properties and mungbean yield. Soil chemical properties at pod-filling stage were also plotted against mungbean yield, but no correlation was found. This is simply because all the chemical properties plotted against the yield lay at the optimum level. Soil pH lay around 7.2 and soil EC values were mainly distributed around 0.2. These values were also very close to the optimum for soybean growth. Accordingly, 5 to 10, 50 to 70, and 45 to 65 ppm were the optimum concentrations of N, P_2O_5, and K_2O at flowering, respectively, for the mungbean growth.

Table 39. Correlation coefficients between soil chemical properties and the yield of soybean cultivar Kaohsiung 8.

	Correlation Coefficients[z]							
	NH_4-N	NO_3-N	pH	EC	Totaln[y]	Totdw[x]	100wt[w]	Yield
NH_4-N	1.0000	0.2801	-0.4624	0.4839	0.9233	0.0298	0.1453	-0.3856
	**	NS	*	**	**	NS	NS	*
NO_3-N	0.2801	1.0000	0.4979	-0.2214	0.6273	0.1880	0.3205	0.4872
	NS	**	**	NS	**	NS	NS	**
pH	-0.4624	0.4979	1.0000	-0.8210	-0.1758	0.3122	0.1296	0.8642
	*	**	**	**	NS	NS	NS	**
EC	0.4839	-0.2214	-0.8210	1.0000	0.3038	-0.4918	-0.0163	-0.8298
	**	NS	**	**	NS	**	NS	**
Totaln[y]	0.9233	0.6273	-0.1758	0.3038	1.0000	0.0985	0.2457	-0.1183
	**	**	NS	NS	**	NS	NS	NS
Totdw[x]	0.0298	0.1880	0.3122	-0.4918	0.0985	1.0000	0.3605	0.6059
	NS	NS	NS	**	NS	**	NS	**
Plant height	-0.1206	0.4081	0.6859	-0.6922	0.0649	0.7402	0.2470	0.8057
	NS	*	**	**	NS	**	NS	**
SED/T	0.1027	-0.2625	-0.1935	0.0410	-0.0210	0.1247	-0.2975	-0.2110
	NS	NS	NS	NS	NS	NS	NS	NS
SD/P[v]	0.0443	0.0720	0.0713	-0.1729	0.0648	0.3195	0.2347	0.2195
	NS	NS	NS	NS	NS	NS	NS	NS
Seed wt	-0.0374	-0.0792	0.1975	-0.4863	-0.0628	0.8425	0.0153	0.4366
	NS	NS	NS	**	NS	**	NS	*
100wt[w]	0.1453	0.3205	0.1296	-0.0163	0.2457	0.3605	1.0000	0.3009
	NS	NS	NS	NS	NS	NS	**	NS
Yield	-0.3856	0.4872	0.8642	-0.8298	-0.1183	0.6059	0.3009	1.0000
	*	**	**	**	NS	**	NS	**

[z]NS = not significant; * = significant at the 5% level; ** = significant at the 1% level. [y]Totaln = Total leaf number. [x]Totdw = Total dry weight. [w]100wt = 100-seed wt. [v]SD/P = Seed no./pod.

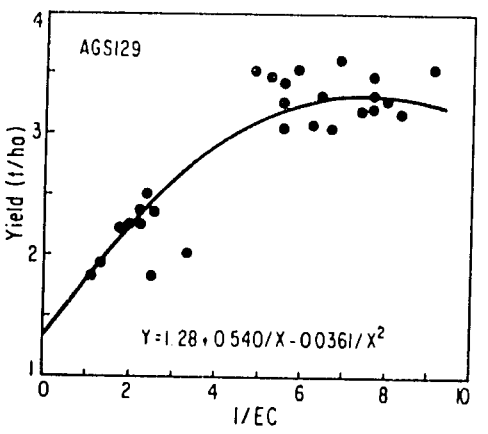


Fig. 27. Effect of soil EC on yield of AGSI29.

Conclusion

Soil pH and EC had a great effect on soybean yield and the yield increased by 0.5 and 0.4 t/ha for every unit increase in pH value for AGS129 and KS8, respectively. For mungbean growth, 7.2, 0.2, 5 to 10, 50 to 70, and 45 to 65 ppm were the optimum levels for soil pH, EC, N, P_2O_5, and K_2O, respectively.

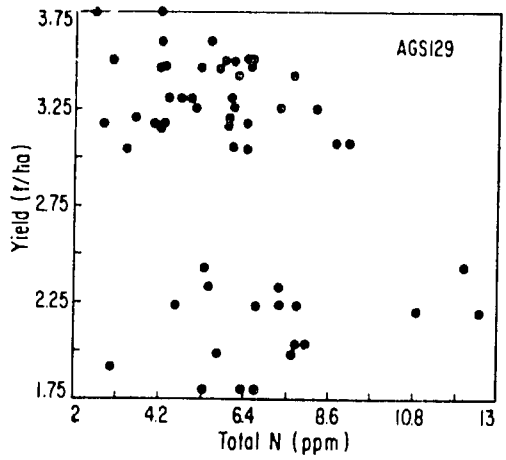


Fig. 28. (left) Effect of soil nitrogen concentration on yield of AGS129.

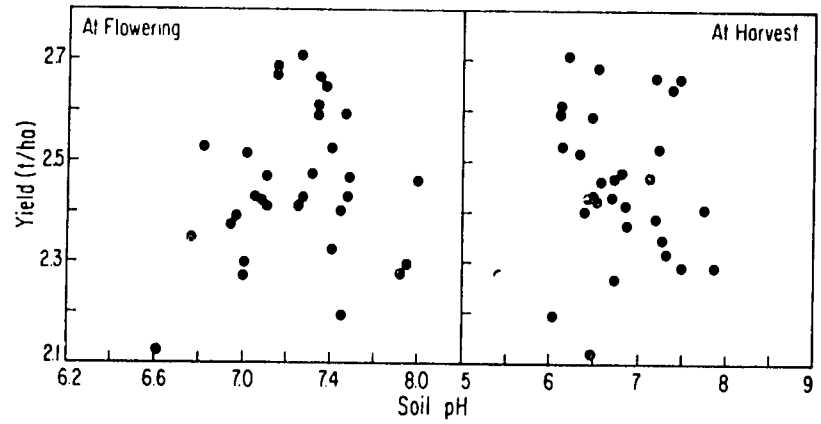


Fig. 29. Effect of soil pH at flowering and harvest on mungbean yield.

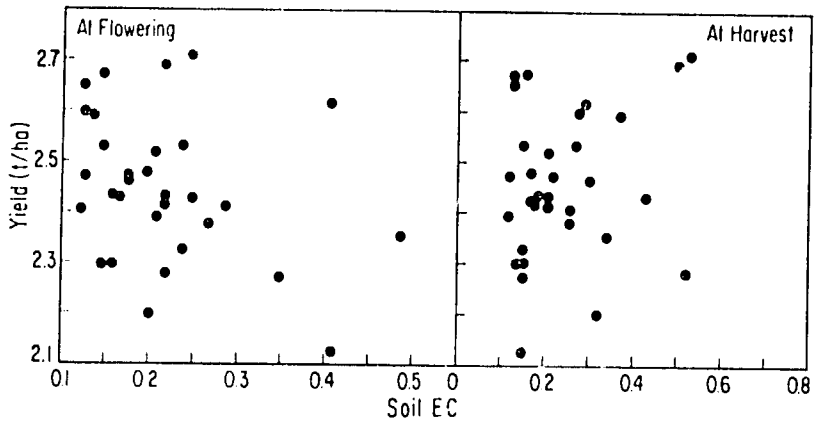


Fig. 30. Effect of soil EC at flowering and harvest on mungbean yield.

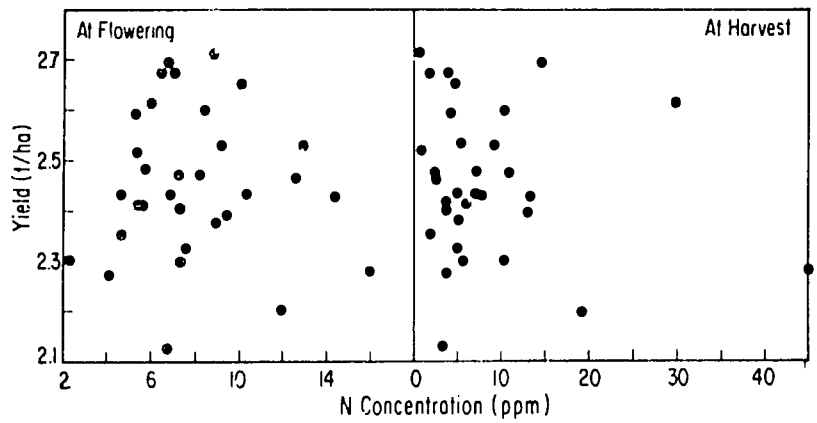


Fig. 31. Effect of soil nitrogen concentration at flowering and harvest on mungbean yield.

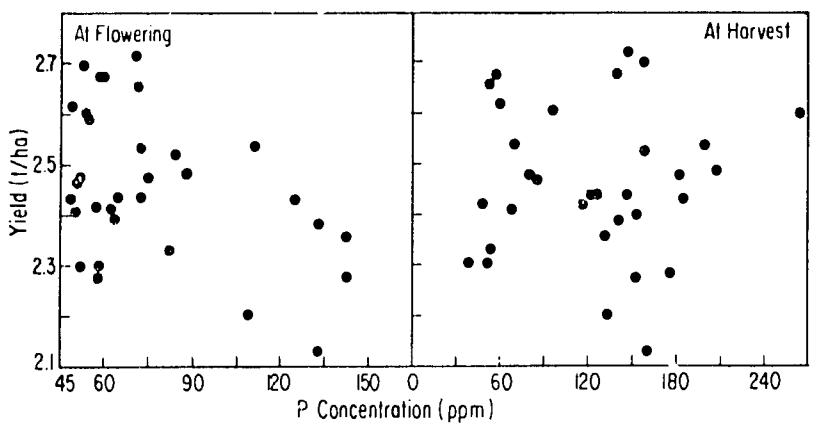


Fig. 32. Effect of soil phosphorus concentration at flowering and harvest on mungbean yield.

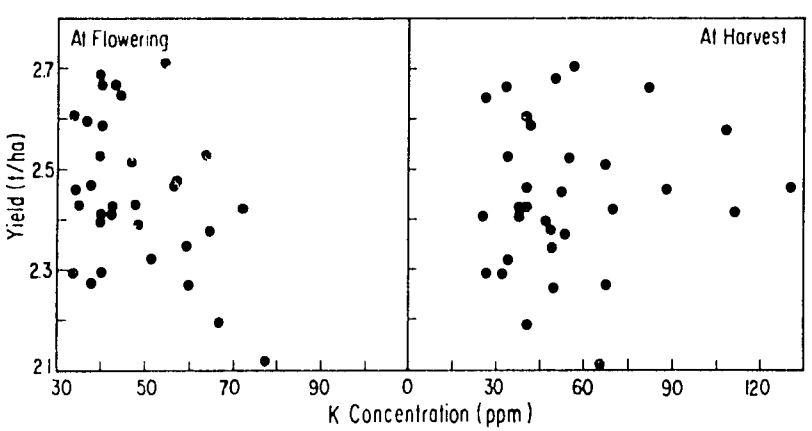


Fig. 33. Effect of soil potassium concentration at flowering and harvest on mungbean yield.

-411-

Training, Conservation, and Information Services

413

Training and Development Office

AVRDC Training Program

Training and Funding

In 1984 AVRDC provided 158 man-months or 13.16 man-years of training to 64 participants from 12 countries (Table 1). Their distribution by commodity is shown in Table 2. In the same year AVRDC initiated a two-week intensive Vegetable Garden Course sponsored by the German Agency for Technical Cooperation (GTZ) with 14 participants from four countries.

The total amount spent for training was US$176,130, 52% of which came from AVRDC and 48% from outside agencies sponsoring training participants, as follows: MARDI/AVRDC Research Program (MARP); USAID - Garden Program; University of Illinois; Heung Nung Seed Company; Bayer Thai Company; Taiwan Ministry of Foreign Affairs; Taiwan Vocational Assistance Commission for Retired Servicemen (VACRS); GTZ; and FELDA Agricultural Services Corporation.

AVRDC provided US$88,568.87 in scholarship grants to 19 scholars from national programs in Korea, Philippines, Taiwan, and Thailand. We also provided financial assistance to 18 summer students from several Taiwan universities to complete training in 36 man-months or three man-years.

The 37 scholars funded by AVRDC representing 129 man-months or 10.75 man-years were: Research Interns (16), Research Fellow (1), Special Purpose Trainees (2), and Summer Student Trainees (18). Since the inception of this program, AVRDC has trained a total of 537 scholars (Table 3).

TOP/AVRDC Production Training Program

The third Regional Training Class held at the Thailand Outreach Program - Asian Vegetable Research and Development Center (TOP/AVRDC) began in October 1984 with an enrollment of 19 persons coming from six Asian countries. The 19 participants were distributed among the five AVRDC mandate crops, as follows: Chinese cabbage (3), tomato (4), sweet potato (4), mungbean (3), soybean (2), and tissue culture (2).

Nine project titles in three crops (Chinese cabbage, tomato, and sweet potato) have already been approved and in effect for research work. Since 1983 when this program started, it has trained 40 production trainees from 10 countries (Table 4).

Table 1. Number of 1984 trainees by country.

Country	Number	Country	Number
Guatemala	1	Philippines	6
Indonesia	7	Republic of China	21
Korea	5	Sierra Leone	1
Liberia	1	Thailand	15
Malaysia	2	U.S.A	1
Nepal	1	West Germany	3
Total			64

Table 2. Number of 1984 trainees by commodity and by category.[z]

Crop	RI	RS	RF	SST	SPT	Total
Horticultural						
Chinese cabbage	6	–	–	5	–	11
Sweet potato	2	–	–	3	–	5
Tomato	5	1	1	5	–	12
Legume						
Mungbean	–	–	–	4	–	4
Soybean	3	–	–	3	–	6
Others	–	1	–	–	27	28
Total	16	2	1	20[y]	28	66

[z]RI = research intern, RS = research scholar; RF = research fellow; SST = summer student trainee; SPT = special purpose trainee [y]Summer student Mr. Yang, Yun-liang is involved in three crops.

Table 3. Number of trainees by category cumulative as of December 31, 1984.[z]

Year	RI	RS	RF	PT	SST	SPT	Total
1974	–	2	–	–	–	–	2
1975	10	1	1	–	8	1	21
1976	14	1	–	24	15	1	55
1977	11	1	–	–	14	5	31
1978	12	4	1	21	17	4	59
1979	2	4	–	25	8	26	65
1980	7	4	1	18	10	4	44
1981	14	–	1	17	11	15	58
1982	15	1	1	16	19	19	71
1983	23	2	3	9	15	15	67
1984	16	2	1	–	18	27	64
Total	124	22	9	130	135	117	537

[z]RI = research intern, RS = research scholar; RF = research fellow; SST = summer student trainee; SPT = special purpose trainee PT = production trainee.

Table 4. Number of TOP/AVRDC trainees by country as of December 1984.[z]

Country	Number	Country	Number
Bangladesh	5	Nepal	1
China	8	Pakistan	1
Indonesia	4	Philippines	1
Kenya	1	Sri Lanka	13
Malaysia	2	Thailand	4
Total			40

[z]All production trainees

Training Scholars

Chinese Cabbage

Calibo, Juanita G., Philippines
Chao, Yu Chane, Taiwan
Che, Chun-liang, Taiwan
Huang, Ji Wei, Taiwan
Na, Jong Hyeon, Korea
Ong, Char Lan, Taiwan
Park, Yang Ho, Korea
Pipithsangchan, Soontorn, Thailand
Toledo Pepe, E., Philippines
Yaur, Meei Jir, Taiwan
Yuenyongsawad, Chamleon, Thailand

Mungbean

Chou, Shwu Chuan, Taiwan
Her, An Shwu, Taiwan
Lin, Ming Chun, Taiwan
Yang, Yun-liang, Taiwan

Soybean

Jene-kritiyo, Anuwat, Thailand
Chang, Yoke Chen, Taiwan
Chin, Moon Sup, Korea
Lee, Kia-hwa, Taiwan
Raymundo, Reynaido L., Philippines
Yang, Yun-liang, Taiwan

Sweet Potato

Chung, Tsuey Pyng, Taiwan
Lee, Yih-chung, Taiwan
Low, Sheng-shyan, Taiwan
Neri, Felino R., Philippines
Yang, Yun-liang, Taiwan

Tomato

Adhikari, Rishi Raj, Nepal
An, Jo Feng, Taiwan
Chen, Yuh-fen, Taiwan
Dittapongpitch, Vanla, Thailand
Kim, Hyeong Do, Korea
Kuo, Ming Ling, Taiwan
Lee, Kyeong Koog, Korea
Leu, Her Sheng, Taiwan
Lin, Yu Hsin, Taiwan
Pratoomrat, Niramit, Thailand
Sheu, Shyang Chwen, Taiwan
Wang, Shyh Shyan, Taiwan

Two-Week Vegetable Production and Home Garden Program

Ali, Wirda, Indonesia
Andreas Triyanto, Indonesia
Dekena, Heiko, W. Germany
Gblee, T. Isaac, Liberia
Imtias Basa, Indonesia
Jaya, Asmar, Indonesia
Kai-Tongi, David P., Sierra Leone
Lorenz, Christoph, W. Germany
Posadas, Nancy, Philippines
Rusli Gibak, Indonesia
Saleh, Atmadi, Indonesia
Schmidt, Andreas, Philippines
Versola, Elizabeth, Philippines
Zaini, Rahmat, Indonesia

Plant Protection

Jullapun, Paryup, Thailand
Leelaamornsin, Prayoon, thailand

Home Garden

Yamboonchoo, Thararag, Thailand

Agricultural Economics

Gleason, Jane, U.S.A.

Others

Disyabutra, Laksana, Thailand
Laosuwan, Paisan, Thailand
Matta, Helmut Cardona, Guatemala
Noppadol, Toatong, Thailand
Pairat Kamdee, Thailand
Rahmat Jamhari, Malaysia
Rodkachane, Pattamarat, Thailand
Saharan, Hj. Anang, Malaysia
Siraprapapong, Orasa, Thailand
Sompong, Puntong, Thailand

Development Program

Sweet Potato

Regional yield trial. Five AVRDC promising sweet potato lines and one improved line from Chiayi Taiwan Agricultural Research Institute (TARI) were tested against two local checks in eight locations for regional yield trial (SPRYT) in spring, summer, and autumn 1984 (Table 1).

In the spring trial, the average marketable root yield from three locations showed CN942-47 topping in yield which was 17% higher then that of the local checks, followed by CN1232-9 (Table 2).

In the summer trial in four different locations, all tested lines performed less in yield then the local check TN66 with only CN1108-13 yielding close to it (Table 3). The fall trial conducted in AVRDC showed CN941 32 giving a yield 59% higher then the local check and CN1232-9 and CN1219-1 with yield 29% higher (Table 4).

Pooling all the three trials together, CN1232 9 and CN1108-13 were the best yielders, but the differences among all entries were not significant (Table 5).

Table 1. Locations, planting dates, and harvesting dates of the sweet potato regional yield trials, Taiwan 1984.

Location	Season	Cooperating Station	Planting Date	Hrvesting Date	Duration (days)
AVRDC	Spring	AVRDC	Mar. 22, 1984	Aug. 30, 1984	160
Taoyuan	Spring	Taoyuan DAIS	Mar. 30, 1984	Sept. 6, 1984	160
Shalu	Spring	Taichung DAIS	Apr. 5, 1984	Aug. 17, 1984	134
AVRDC	Summer	AVRDC	May 28, 1984	Nov. 13, 1984	168
Kinshan	Summer	Taoyuan DAIS	Apr. 27, 1984	Sept.17, 1984	143
Penghu	Summer	Kaohsiung DAIS	May 11, 1984	Oct. 17, 1984	160
Chingsui	Summer	Chiayi TARI	June 14, 1984	Oct. 26, 1984	134
AVRDC	Autumn	AVRDC	Aug. 24, 1984	Jan. 30, 1985	160

Table 2. Marketable root yields and quality evaluation of entries in the Taiwan sweet potato regional yield trials, spring 1984.[z]

Entry	Marketable Root Yield (t/ha)				Index	Percentage of Dry Weight (AVRDC)				
	Taoyuan	Shalu	AVRDC	mean		dry matter	protein	sugar	starch	fiber
CN941-32	39.4a	21.3cd	16.3c	25.7	95	24.9b	1.57c	14.8bc	70.5ab	1.51cd
CN1108-13	31.1bc	24.9bc	24.2b	26.7	99	21.6b	1.55c	17.9a	67.7bc	1.59c
CN1232-9	31.6bc	30.8a	25.9ab	29.4	109	23.4c	2.99a	14.0c	63.6cd	2.33ab
CN1219-1	28.5cd	17.7d	15.7c	20.6	76	22.8c	1.95bc	15.5bc	65.6cd	2.09b
CN942-47	35.2ab	26.9ab	32.9a	31.7	117	22.6cd	2.08b	18.3a	63.2d	2.44a
63-74	27.0cd	20.8cd	27.9ab	25.2	93	33.4a	1.77bc	8.9d	74.4a	1.27d
Tainung 64 (Ck1)	23.6d	23.4bc	25.4ab	24.1	89	23.5c	2.08b	17.9a	64.9cd	2.21ab
Tainung 66 (Ck2)	34.7ab	22.6bc	23.7b	27.0	100	23.2c	2.88a	16.6ab	64.4cd	2.26ab

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 3. Marketable root yields and quality evaluation of entries in the Taiwan sweet potato regional yield trials, summer 1984.[z]

Entry	Marketable Root Yield (t/ha)					Index	Percentage of Dry Weight (AVRDC)				
	Kinshan	Penghu	Chingsui	AVRDC	mean		dry matter	protein	sugar	starch	fiber
CN941-32	16.3e	6.6c	9.4d	16.5	12.3	58	24.5d	4.27	18.8	63.3	1.7
CN1108-13	32.5a	12.6a	20.6ab	16.3	20.5	96	27.5c	4.39	18.9	60.7	1.8
CN1232-9	23.9b	6.6c	18.1bc	19.0	16.9	79	28.2c	5.18	18.5	59.8	2.0
CN1219-1	21.3cd	5.4c	16.9bc	14.4	14.5	68	31.7b	4.16	16.3	61.6	2.2
CN942-47	19.2d	6.5c	18.0bc	19.8	15.9	74	27.8c	3.94	19.5	60.6	1.9
63-74	15.8e	9.7b	16.0c	16.3	14.4	67	37.7a	4.53	20.3	60.2	2.0
Tainung 64 (Ck1)	22.0bc	5.1c	6.6d	14.0	11.9	56	27.1c	4.56	18.4	60.8	1.9
Tainung 66 (Ck2)	32.1a	12.2a	22.1a	19.4	21.4	100	27.2c	4.19	19.1	62.0	1.9

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 4. Marketable root yields and quality evaluation of entries in the Taiwan sweet potato regional yield trial, autumn 1984.[z]

Entry	Marketable Root Yield in AVRDC (t/ha)	Index	Percentage of Dry Weight				
			dry matter	protein	sugar	starch	fiber
CN941-32	22.4a	159	24.3d	2.35d	17.3b	67.0c	1.80c
CN1108-13	17.2b	122	26.9bc	2.32d	13.5cd	72.3b	1.54cd
CN1232-9	18.2b	129	27.2b	3.37ab	12.4d	68.3c	1.79c
CN1219-1	18.2b	129	29.8a	3.62a	9.6e	74.2ab	1.39d
CN942-47	16.5bc	117	23.9d	2.36d	19.1a	63.2d	2.28a
63-74	16.4bc	116	30.8a	2.55cd	9.9e	76.2a	1.29d
Tainung 64 (Ck1)	11.5d	82	26.0c	2.84bcd	16.5b	63.5d	2.17ab
Tainung 66 (Ck2)	14.1cd	100	26.6bc	3.17abc	14.6c	65.7cd	1.91bc

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Chinese Cabbage

Regional yield trial. In its second year, this regional yield trial (CCRYT) was conducted in summer 1984. Five AVRDC promising lines and three check varieties were tested in eight locations representing the major production areas in Taiwan. Owing to heavy rainfall damage during the seedling stage and serious soft rot infection during the harvesting stage, the Fengshan Tropical Horticultural Experiment Station (FTHES) failed to gather yield data. Table 6 shows only the results from the seven other regions.

Though AVRDC 80-37 gave the highest average yield of 20.82 t/ha among the five selected lines, it was, however, 11% lower than that of the check variety ASVEG 1, and was more sensitive to soft rot. Hence, no results were considered outstanding.

Because the Taiwanese preferred the Chang-puh type, Chinese cabbage with smooth, dark green leaves and compact heads commanded a better market price. Only AVRDC 80-6, 80-12, and 80-13 nearly fitted these descriptions, thus, they were selected for the 1985 CCRYT.

Processing Tomato

Regional yield trial. For the cropping season extending from 1983 to 1984, nine AVRDC promising processing tomato lines were tested in a regional yield trial (PTRYT) against three local cultivars at three locations in late summer, fall, and winter (Table 7). In the 1983 late summer trial, TM103 gave a yield 52% higher than that of the check (Tainan No. 2) followed by PT857. PT8762 produced the biggest fruits followed by PT858 (Table 8).

In the fall trial, the yield of all entries were over 100 t/ha, with TM102 giving an average yield 28% higher than that of the check, and with PT862 having the second highest yield. On the other hand, PT858, however, again produced the biggest fruits (Table 9). In the winter planting, TM103 yielded 89% better than the check and PT858 again topped all entries on mean fruit weight (Table 10).

In all the three-season trials, TM103 was the top yielder and the fall planting produced the highest average yield of 122.2 t/ha. Late winter planting should be avoided for low yield (Table 11). Based mainly on yield, fruit appearance, and processing qualities, TM103, PT858, and PT862 were again included in the district trials of 1984.

Frozen tomato observation trial. The frozen processing tomato observation trial was initiated in September 1983 to test five AVRDC promising lines against two local cultivars in AVRDC and Ahlien. PT913 gave the highest average yield 29% higher than that of the check Known-you 209, followed by PT912 (Table 12). In view of the excellent yield performance of PT913 which has good fruit color, shape, and heat tolerance, it was commended as a potential line.

Fresh-Market Tomato

Regional yield trial. This regional yield trial for summer fresh-market tomato (FMTRYT) was conducted in six locations representing the major production areas in Taiwan, to test five AVRDC promising lines and three newly bred lines from Taiwan Seed Improvement Production Station (TSIPS).

The trials in Yangmingshan and Yu-chih areas failed to give yield data owing to bacterial wilt and early blight damage brought about by heavy rains. In the Seapao area of Hualien District Agriculture Improvement Station (DAIS), CL5573 gave the biggest average fruit weight and highest yield which was 7% higher than that of the check TSS No. 1 (Table 13).

CL1405 gave the best yield which were 22% higher than that of the local check in Puli (Table 14). Again CL5573 was the best yielder in the Sanchung Branch Station trial (Table 15).

Due to their sensitivity to bacterial wilt, AVRDC's lines gave yield much lower than the local checks in the TSIPS trial where C325 topped all entries with a yield 53% higher than that of the check (Table 16).

Table 5. Marketable root yields and quality evaluation of entries in the 1984 Taiwan sweet potato regional yield trials.

Entry	Marketable Root Yield (t/ha)				Index	Percentage of Dry Weight				
	spring	summer	autumn	mean		dry matter	protein	sugar	starch	fiber
CN941-32	25.7	12.3	22.4	20.1	97	24.6	2.73	17.0	66.9	1.67
CN1108-13	26.7	20.5	17.2	21.5	103	25.3	2.75	16.8	66.9	1.64
CN1232-9	29.4	16.9	18.1	21.5	103	26.3	3.85	15.0	63.6	2.04
CN1219-1	20.6	14.5	18.2	17.8	86	28.1	3.24	13.8	67.1	1.89
CN942-47	31.7	15.9	16.5	21.4	103	24.8	2.79	19.0	62.3	2.21
63-74	25.2	14.4	16.4	18.7	90	34.0	2.95	13.0	70.3	1.52
Tainung 64 (Ck1)	14.1	11.9	11.5	12.5	60	25.5	3.16	17.6	63.1	2.09
Tainung 66 (Ck2)	27.0	21.4	14.1	20.8	100	25.7	3.41	16.8	64.0	2.02

Table 6. Yields and horticultural characters of entries in the Taiwan Chinese cabbage regional yield trials, summer 1984.[z]

Entry	Yield (t/ha)								Index	Days to Maturity	Mean Head Wt (g)	Head Shape Index	Harvest Rate (%)
	AVRDC	Tainan DAIS	Kaohsiung DAIS	Shanchung BS	Taoyuan DAIS	Taichung DAIS	Hualien DAIS	mean					
AVRDC 80-6	15.33b	27.60ab	7.62bcd	26.35	26.24	26.39cd	11.72	20.18ab	86	41.0	611.5	1.31	85.5
AVRDC 80-12	14.01b	23.30c	6.17cd	22.68	24.85	25.15d	10.73	18.13b	77	41.0	588.5	1.45	82.8
AVRDC 80-13	16.56b	25.30c	7.26bcd	25.30	28.58	25.34d	9.98	19.76ab	84	41.4	651.4	1.32	81.6
AVRDC 80-32	16.11b	17.60d	10.10abc	23.10	23.87	30.81bc	8.44	18.58b	79	41.1	628.1	1.30	81.5
AVRDC 80-37	14.86b	23.00c	10.79ab	26.38	29.99	34.19ab	6.56	20.82ab	89	41.3	685.7	1.42	80.7
ASVEG No. 1	14.67b	31.10a	11.04a	28.58	31.60	37.00bc	10.05	23.43a	100	41.7	709.4	1.29	84.4
MC8221	19.51a	29.00a	12.72a	25.35	30.32	30.71bc	14.47	23.15a	99	41.1	704.0	1.25	89.0
Win Wu	13.85b	13.00e	4.98d	27.18	21.24	33.94ab	14.14	18.33b	78	45.9	752.3	1.63	66.7
LSD (0.05)	2.584	0.351	3.896	n.s.	n.s.	4.735	n.s.	3.437					

[z]Dates sown: AVRDC, June 1; Tainan DAIS, May 7; Kaohsiung DAIS, June 29; Shanchung BS, July 20; Taoyuan DAIS, July 27; Taichung DAIS, July 30; Hualien DAIS, May 3. Date transplanted: AVRDC, June 19; Kaohsiung DAIS, July 16; Hualien DAIS, May 29. Dates harvested: AVRDC, July 27-Aug. 3; Tainan DAIS, June 25-29; Kaohsiung DAIS, Aug. 9-20; Shanchung BS, Sept. 27-Oct. 5; Taoyuan DAIS, Oct. 2-13; Taichung DAIS, Oct. 3-15; Hualien DAIS, July 6. Mean separation within columns by Duncan's multiple range test as 5% probability level.

Table 7. Locations, planting dates, and harvesting dates of the processing tomato regional yield trial at Taiwan, 1983 to 1984.

Location	Season	Cooperating Station	Date Sown	Date Planted	Date Harvested
AVRDC	Late summer	AVRDC	July 15	Aug. 4	Oct.20 – Jan. 5
Tungshish	Late summer	Tainan DAIS	July 15	Aug. 9	Nov. 7 – Jan.26
Shuilin	Late summer	Tainan DAIS	July 15	Aug. 5	Nov. 8 – Jan.26
AVRDC	Autumn	AVRDC	Sept.15	Oct.15	Jan.16 – Mar. 9
Tungshish	Autumn	Tainan DAIS	Sept.15	Oct.15	Jan.19 – Mar.12
Shuilin	Autumn	Tainan DAIS	Sept.15	Oct.12	Jan. 2 – Mar.23
AVRDC	Winter	AVRDC	Nov. 15	Dec.15	Apr. 5 – May 3
Tungshih	Winter	Tainan DAIS	Nov. 15	Dec.15	Apr.15 – May 15
Shuilin	Winter	Tainan DAIS	Nov. 15	Dec.15	Apr.26 – May 15

Table 8. Yields and horticultural characters of entries in the Taiwan processing tomato regional yield trials, late summer 1983 to 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	Fruit Size (g)	pH	Soluble Solids (°Brix)	Titratable Acidity (%)	Hunter Color (a/b)
	AVRDC	Tainan DAIS		mean							
		Tungshih	Shuilin								
TM102	61.1cde	70.3abcd	42.9	58.1bc	115	143.8	74.0	4.18	5.07	0.380	2.62
TM103	83.2a	83.5ab	63.5	76.7a	152	129.8	57.3	4.19	4.58	0.366	2.57
PT867	–	71.2abcd	55.0	63.1bc	125	141.7	66.1	4.24	4.53	0.415	2.54
PT870	–	75.2abc	56.9	66.1ab	131	124.9	65.2	4.23	4.88	0.475	2.56
PT873	–	73.7abcd	43.3	58.5bc	116	137.8	70.1	4.33	4.94	0.373	2.49
PT857	72.1abc	88.6a	51.6	70.8ab	141	131.7	73.2	4.20	4.93	0.341	2.56
PT858	65.5bcd	73.2abcd	60.6	66.4ab	132	132.0	77.8	4.20	4.64	0.368	2.50
PT862	66.4abcd	61.8bcd	51.5	59.9bc	119	134.9	78.9	4.24	5.34	0.342	2.79
CL2815	49.9def	68.5abcd	54.1	57.5bc	114	148.0	60.1	4.20	4.55	0.413	2.57
TK10	62.3cde	62.4bcd	48.4	57.7bc	153	140.7	75.6	4.15	5.01	0.481	2.59
TK70	35.8f	52.2d	42.9	43.6d	87	152.4	76.3	4.26	5.45	0.461	2.62
Tainan No. 2	46.5ef	54.5cd	50.3	50.4cd	100	152.0	63.7	4.23	4.78	0.387	2.88
LSD (0.05)	15.3	18.761	n.s.	11.585							

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 9. Yields and horticultural characters of entries in the Taiwan processing tomato regional yield trials, autumn 1983 to 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	Fruit Size (g)	pH	Soluble Solids (°Brix)	Titratable Acidity (%)	Hunter Color (a/b)
	AVRDC	Tainan DAIS		mean							
		Tungshih	Shuilin								
TM102	106.4	129.2	173.5	136.4a	128	131.5	62.5	4.29	5.44	0.447	2.501
TM103	84.3	139.2	147.3	123.6abc	116	126.4	61.4	4.34	4.76	0.399	2.507
PT867	89.7	126.2	132.8	116.2bcd	109	124.6	63.7	4.34	5.16	0.428	2.373
PT870	100.9	130.9	158.0	129.9ab	122	130.8	65.0	4.33	4.84	0.429	2.476
PT873	99.2	124.6	156.4	126.7abc	119	129.5	70.0	4.35	5.18	0.394	2.311
PT857	101.1	122.3	157.7	127.0ab	119	131.3	60.8	4.33	5.21	0.457	2.522
PT858	78.7	126.4	156.1	120.4abcd	113	128.0	75.9	4.34	5.17	0.450	2.591
PT862	96.2	137.1	165.1	132.8ab	125	128.6	68.2	4.35	5.50	0.429	2.500
CL2815	85.5	133.0	143.9	120.8abcd	113	132.5	56.4	4.32	4.50	0.422	2.459
TK10	82.1	128.0	137.2	115.8bcd	109	128.0	70.9	4.26	4.72	0.496	2.554
TK70	73.8	122.9	133.1	109.9cd	103	134.4	67.2	4.29	4.92	0.452	2.429
Tainan No. 2	73.5	126.9	119.5	106.6d	100	132.9	67.1	4.47	5.09	0.332	2.585
LSD (0.05)	n.s.	n.s.	n.s.	14.910							

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 10. Yields and horticultural characters of entries in the Taiwan processing tomato regional yield trials, winter 1983 to 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	Fruit Size (g)	PH	Soluble Solids (°Brix)	Titratable Acidity (%)	Hunter Color (a/b)
	AVRDC	Tainan DAIS		mean							
		Tungshih	Shuilin								
TM102	40.9abc	43.8	28.4d	37.7	135	137.1	64.1	4.36	5.49	0.468	2.536
TM103	42.2ab	59.9	56.9a	53.0	189	128.3	64.9	4.28	4.53	0.446	2.346
PT867	45.3a	51.6	51.5ab	49.5	177	130.6	64.7	4.26	4.74	0.472	2.412
PT870	44.7a	58.0	21.7de	41.5	148	136.6	63.9	4.39	4.49	0.392	2.403
PT873	34.1abc	58.5	48.5b	47.0	168	128.3	77.9	4.32	4.69	0.407	2.466
PT857	45.3a	56.3	22.0de	41.2	147	137.4	65.8	4.26	4.70	0.417	2.582
PT858	27.2c	46.7	48.8b	40.9	146	129.9	82.0	4.32	5.32	0.367	2.413
PT862	34.6abc	49.7	40.6c	41.6	149	129.3	78.8	4.13	5.25	0.457	2.366
CL2815	26.9c	51.9	22.2de	33.7	120	137.0	59.1	4.38	4.22	0.445	2.237
TK10	29.2bc	41.5	37.0c	35.9	128	130.7	75.7	4.37	4.87	0.484	2.466
TK70	33.1abc	46.4	25.5d	35.0	125	137.2	69.0	4.40	5.58	0.513	2.306
Tainan No. 2	31.2abc	36.3	16.4e	26.0	100	139.6	71.1	4.34	5.14	0.430	2.697
LSD (0.05)	12.672	n.s.	6.898	n.s.							

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 11. Mean yields of entries in three seasons of the processing tomato regional yield trials, Taiwan 1983 to 1984.

Entry	Yield (t/ha)				Index
	late summer	autumn	winter	mean	
TM102	58.1	136.4	37.7	77.4	125
TM103	76.7	123.6	53.0	84.4	137
PT867	63.1	116.2	49.5	76.3	124
PT870	66.1	129.9	41.5	79.2	123
PT873	58.5	126.7	47.0	77.4	125
PT857	70.8	127.0	41.2	79.7	129
PT858	66.4	120.4	40.9	75.9	123
PT862	59.9	132.8	41.6	78.1	127
CL2815	57.5	120.8	33.7	70.7	115
TK10	57.7	115.8	35.9	69.8	113
TK70	43.6	109.9	35.0	62.8	102
Tainan No. 2	50.4	106.6	28.0	61.7	100
LSD (0.05)	11.585	14.910	n.s.	11.548	

Table 12. Yields and horticultural characters of entries in the Taiwan frozen processing tomato observation trials in autumn 1983.[z]

Entry	Yield (t/ha)			Index	Days to Maturity	Fruit Size (g)
	AVRDC	Tainan DAIS Ahlien	mean			
PT912	71.1a	42.8a	57.0	127	118	23.5
PT913	77.8a	37.9a	57.9	129	118	23.7
L123	60.6a	16.2c	38.4	86	118	23.7
L123	60.6a	16.2c	38.4	86	118	25.6
L4128a	45.8b	17.6c	31.7	71	118	18.2
CL1131-0 -0-38-4-0	46.8b	22.5bc	34.7	78	119	14.5
Known You 209	64.7a	24.8b	44.8	100	118	32.5
Golden Citrus	10.1c	12.6d	11.4	25	120	16.4
LDS (0.05)	16.713	6.590			n.s.	

[z]Date transplanted: AVRDC Sept. 14, 1983, Ahlien, Sept. 13, 1983; Date harvested: AVRDC, Dec. 28, 1983 to Jan. 16, 1984, Ahlien, Nov. 24, 1983 to Jan. 22, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 13. Yields and horticultural characters of entries in the Taiwan fresh market tomato regional yield trial at Hualien DAIS in summer 1984.[z]

Entry	Yield (t/ha)	Index	Days to Flowering	Days to Maturity	Fruit Size (g)	Soluble Solids (°Brix)
CL1430	99.5a	95	28	71	113	5.2
CL1405	78.2b	75	29	71	80	4.5
CL4805	99.6a	95	29	71	109	5.1
CL4810	101.8a	97	29	75	169	5.3
CL5573	111.8a	107	27	71	170	5.0
CL5571	97.6ab	93	27	74	122	4.7
C331	108.0a	103	29	71	114	4.9
TSS No. 1 (check)	104.8a	100	29	71	93	0.9

[z]Date sown: April 23, 1984, date transplanted: May 24, 1984; date harvested: Aug. 3 to Sept. 25, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 14. Yields and horticultural characters of entries in the Taiwan fresh market tomato regional yield trial at Puli BS in summer 1984.[z]

Entry	Yield (t/ha)	Index	Days to Flowering	Days to Maturity	Fruit Size (g)
CL1430	21.54	59	27	56	43.16
CL1405	44.75	122	27	56	76.81
CL4805	28.82	79	30	56	53.62
CL4810	34.73	95	27	56	50.61
CL5573	27.67	76	27	56	48.33
CL5574	31.22	85	30	56	56.19
C325	27.66	76	24	56	49.80
C331	32.15	88	30	56	57.88
C196	31.29	85	27	56	56.32
TSS No. 1	36.63	100	30	56	65.93

[z]Date transplanted: May 8, 1984; date harvested: June 3, 1984.

Table 15. Yields and horticultural characters of entries in the Taiwan fresh market tomato regional yield trial at Sanchung BS in summer 1984.[z]

Entry	Yield (t/ha)	Index	Days to 1st Harvest	Fruit Size(g)
CL1430	32.6	78	62	76.2
CL1405	37.1	88	62	137.9
CL4805	36.0	86	62	112.5
CL4810	39.9	95	65	146.5
CL5573	42.5	101	62	137.5
C331	40.4	96	56	101.6
TSS No 1	42.0	100	59	123.8

[z]Date sown: April 3,1984, date transplanted: May 16, 1984; date harvested: July 11 to Aug. 24, 1984.

Table 16. Yields and horticultural characters of entries in the Taiwan fresh market tomato regional yield trial at TSIPS summer 1984.[z]

Entry	Yield (t/ha)	Index	Fruit Size (g)
CL1430	0.92	11	56
CL1405	0.82	10	54
CL4805	0	0	0
CL4810	0	0	0
CL5573	0.03	0	128
CL5574	0	0	0
C331	10.10	118	121
C325	13.07	153	95
C196	12.33	144	119
TSS No. 1	8.57	100	115

[z]Date sown: June 21, 1984; date transplanted: July 15, 1984; date harvested: Sept. 12 to Oct. 20, 1984. TSIPS = Taiwan Seed Improvement Station.

Mungbean

Regional yield trial. In spring 1984, VC2764A topped 10 participating selections in the mungbean regional yield trial (MBRYT) conducted by AVRDC, with an average yield 10% higher than that of the local check Tainan No. 3 (Tables 17 and 18). The yields of the rest were lower than that of the check.

District trial. In spring 1984, the mungbean district trial (MBSR) was conducted in Yichu, Sheichia, and AVRDC. VC2764A gave a higher (but not significant) average yield than the local check Tainan No. 3 (Table 19).

In the summer 1984 trial conducted in five locations (AVRDC, Tainan, Taipao, Yenshui, and Sheichia), five promising "dull" lines and three "shiny" lines were tested. VC2530A (dull) and VC2764A (shiny) were included from the spring trial. Table 20 shows that the local check Tainan No. 3 outyielded all entries. VC2768A and VC2764A (both shiny) and VC1168B and VC2530C (both dull) gave comparable yields, however.

Dull varieties with better eating qualities sell well in the Taiwan market. So, farmers demand dwarf, high-yielding varieties with uniform maturity and resistance to powdery mildew. VC1168B and VC2530C nearly fit this description.

Table 17. Locations, planting dates, and harvesting dates of the mungbean regional yield trials, Taiwan 1984.

Location	Season	Cooperating Station	Date Sown	End of Harvest
AVRDC	Spring	AVRDC	March 5	June 21
Yichu	Spring	Tainan DAIS	March 30	June 25
Sheichia	Spring	Tainan DAIS	Feb. 27	May 17
AVRDC	Summer	AVRDC	July 13	Oct. 26
Tainan	Summer	Tainan DAIS	July 23	Sept. 30
Taipao	Summer	Tainan DAIS	July 16	Sept. 25
Yenshui	Summer	Tainan DAIS	July 14	Sept. 14
Sheichia	Summer	Tainan DAIS	July 12	Sept. 24

Table 18. Yields and agronomic characters of entries in the mungbean regional yield trial at AVRDC, spring 1984.[z]

Entry	Yield (t/ha)	Days to Maturity	% of 1st yield	Days to Flowering	1000-Seed Wt (g)
VC2764A	2.94a	99	37.8	56	56.8
VC2778A	2.45bc	97	48.5	55	59.2
VC2527A	2.09d	96	54.6	54	59.2
VC2565A	2.51bc	98	46.0	56	56.9
VC1562A	1.92d	98	41.4	54	58.8
VC2530C	2.38c	98	43.1	54	53.5
VC2523A	2.42bc	98	48.0	56	49.9
VC2719A	2.40c	100	34.6	55	53.2
Tainan No. 3	2.67b	97	55.6	55	58.1
VC3476	2.06d	97	52.7	54	48.3
LSD (0.05)	0.245	1.627	9.882	1.710	2.695

[z]Date sown: Feb. 22, 1984, date harvested: May 16 to June 18, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 19. Yields and agronomic characters of entries in the mungbean district trials, spring 1984.[z]

Entry	Yield (t/ha)				Index	Days to Flowering	Days to Maturity	% of 1st Harvest	1000-Seed Wt (g)
	AVRDC	Tainan DAIS		mean					
		Yichu	Sheichia						
VC2527A	2.28a	0.95abc	0.96	1.40a	89	49	89	59	54.7
VC2530C	2.17a	1.23a	1.04	1.48a	94	50	90	57	54.2
VC2565A	2.33a	1.20a	1.19	1.57a	100	51	89	62	54.8
VC2764A	2.55a	1.20a	1.21	1.65a	105	50	90	59	58.0
VC2778A	2.44a	0.98ab	0.99	1.47a	94	50	88	67	61.4
Tainan No.3	2.62a	0.89bc	1.19	1.57a	100	50	88	66	54.6
V5000	1.75b	0.67c	0.73	1.05b	67	51	91	54	45.8
LSD (0.05)	0.391	0.284	n. s.						

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 20. Yields and agronomic characters of entries in the mungbean district trials, summer 1984.[z]

Entry	Yield (t/ha)						Index	Days to Flowering	Days to Maturity	% of 1st Harvest	1000-Seed Wt (g)
	AVRDC	Tainan DAIS				mean					
		Tainan	Taipao	Yenshui	Sheichia						
VC2530C	1.98bc	0.98	1.70a	1.10b	1.25abc	1.40	91	38.0	86.3	55.6	56.7
VC2572A	2.11bc	1.00	1.58a	1.06b	1.19c	1.39	90	41.3	88.9	25.7	59.7
VC1647B	1.77c	1.29	1.30b	0.89c	1.42a	1.33	86	38.0	83.5	62.8	54.7
BC1168B	2.38ab	1.18	1.31b	1.04b	1.41a	1.46	95	40.7	88.3	50.5	57.3
BC1060C	1.97bc	1.09	1.62a	1.03b	1.21bc	1.38	90	38.0	88.0	51.2	59.7
VC2768A	2.15abc	1.18	1.55a	1.24a	1.37abc	1.50	97	40.0	88.6	49.8	61.7
BC2764A	2.37ab	0.98	1.53a	1.15ab	1.38ab	1.48	96	40.7	88.0	51.3	57.3
Tainan No.3	2.54A	1.14	1.53a	1.16ab	1.31abc	1.54	100	41.3	88.5	50.1	56.3
LSD (0.05)	0.379	n.s.	0.163	0.118	0.164			1.208	n.s.	n.s.	0.368

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Vegetable Soybean

Regional yield trials (1983). The 1983 vegetable soybean regional yield trials (VSBRYT) were conducted in seven locations in spring, one location in summer and six locations in autumn (Table 21). Eight AVRDC promising lines were tested against two local cultivars, Tainung 205 and Ryokkoh.

In the spring trial, AGS190 outyielded all entries with the best average in seven locations, but no significant differences in yield were observed among all participating selections. In terms of maturity date, local check Tainung 205 was the earliest (Table 22).

In the summer trial at Puli, check variety Tainung 205 was the best yielder and AGS190 and AGS191, the latest to mature (Table 23). In the autumn trial, most of the selections were harvested within 69-75 days after planting. Again local check Tainung 205 outyielded all others, followed by AGS188, AGS190, and AGS191 with an average yield of 11.5 t/ha (Table 24).

Table 25 shows the overall analysis of the three-season trials in 1983. Although Tainung 205 outyielded all entries, its yield was not significantly different from those of AGS186, AGS188, and AGS189. A uniform and early maturity date was observed for all participating selections in the autumn trial.

All the tested samples had been sent to processing factories for marketing, first in May 9 and 16 and second, in Nov. 22 and 24, 1983. According to the product analysis report of Jen-Shine Factory, six selected lines, AGS184 to AGS189, were rejected by client exporters because they had small seeds and pods. On the other hand, AGS190 with good yield, larger seeds and pods, better taste, and greener (though frozen) color matched the demand of factories. Thus, AVRDC provided 20 kg of AGS190 seeds to Jen-Shine factory for further observation. In summer 1984, AVRDC encouraged some farmer-cooperators to multiply AGS190 seeds for further observation and demonstration trials by the processors.

A field day on May 2, 1983 was held at AVRDC to demonstrate the performance of new selections. There were 42 participants from the Council of Agriculture, Planning Development of Agricultural and Forestry, Taiwan Agricultural Research Institute, Provincial Farmers' Association, District Agricultural Improvement Station and the processing plant. All of them hoped that a better variety be developed to replace declining Tainung 205 which already had high unqualified podding rate, more pods with less than two seeds, and more two-seeded pods not well filled.

Regional yield trials (1984). Continued in 1984, VSBRTYT was conducted at six locations in spring, four locations in summer, and three locations in autumn (Table 26). In the spring trial, AGS186 gave an average yield 15% higher than that of check Tainung 205. Maturity dates were not significantly different among the tested lines (Table 27).

In the summer trial, the differences in yield among lines were insignificant. However, AGS184 matured the earliest at 94.5 days after planting (Table 28). In the fall trial, all entries yielded below 10 t/ha, with AGS191 yielding 12% higher than Tainung 205 (Table 29). AGS187 and Tainung 205 matured the earliest at 68 days after planting.

Pooling all the three trials conducted in 13 locations together, AGS 186 topped with an average yield 5% higher than that of the local check, but differences among all entries were not significant. AGS187 matured earliest (Table 30).

Soybean

Regional yield trial. The spring soybean regional trial (SBRYT) was conducted in Chiyang, Yenpu, and AVRDC to test 12 promising lines from TARI, Hualien DAIS, Kaohsiung DAIS, National Chung Hsiung University, and AVRDC. Table 31 shows check KS8, with the highest yield of 3.08 t/ha, followed by KS1264 and TARI 4. In the summer trial conducted at AVRDC, AGS129 yielded 27% higher than the check, followed by TARI 4 with 2.92 t/ha (Table 32).

Table 21. Locations, planting dates, and harvest dates of the vegetable soybean regional yield trial, Taiwan 1983.

Location	Season	Cooperating Station	Date Planted	Date Harvested
AVRDC	Spring	AVRDC	Feb. 9	May 2 – 16
Puli	"	Taichung DAIS	Mar. 10	May 31 – Jun.22
Houli	"	"	Apr. 12	Jun.27 – Aug.10
Fengyuan	"	"	Apr. 19	July 8 – 21
Tungshih	"	Tainan DAIS	Mar. 3	May 25 – Jun. 7
Yenpu	"	Kaohsiung DAIS	Feb. 7	Apr.30 – May 5
Meilong	"	"	Feb. 7	Apr.28 – May 5
Puli	Summer	Taichung DAIS	Sept.13	Nov.17 – 29
AVRDC	Autumn	AVRDC	Oct. 8	Dec.19 – 26
Houli	"	Taichung DAIS	Sept. 3	Nov.15
Fengyuan	"	"	Aug. 29	Nov. 3 – 16
Peikang	"	Tainan DAIS	Sept. 3	Nov.10 – 14
Likang	"	Kaohsiung DAIS	Oct. 3	Dec. 8 – 19
Meilong	"	"	Oct. 8	Dec.19 – 26

Table 23. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trial at Puli (Taichung DAIS), summer 1983.

Entry	Yield (t/ha)	Index	Days to Maturity	100 Seed-Wt(g)
AGS184	8.47	73.8	90	51.8
AGS185	7.76	67.6	76	67.4
AGS186	8.46	73.7	76	48.7
AGS187	9.07	79.0	70	63.2
AGS188	9.53	83.0	74	73.7
AGS189	10.60	92.3	74	58.7
AGS190	7.53	65.6	91	61.7
AGS191	7.67	66.8	91	60.8
Tainung 205	11.48	100.0	70	76.7
Ryokkoh	8.19	71.3	76	94.9
LSD	1.795			5.60

Table 22. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, spring 1983.[z]

Entry	Yield (t/ha)								Index	Days to Maturity	100-Seed Wt (g)
	AVRDC	Taichung DAIS			Tainan DAIS	Kaohsiung DAIS		mean			
		Puli	Houli	Fengyuan	Tungshih	Yenpu	Meilong				
AGS184	6.85c	3.08f	14.10abcd	–	8.70c	5.55d	7.46cd	7.62	75.7	86.8	43.7
AGS185	7.13bc	3.75ef	16.59ab	6.82	11.28ab	4.67d	5.45d	7.96	79.1	85.0	46.2
AGS186	10.50a	4.13def	16.76ab	10.64	8.65c	7.88bc	11.06ab	9.95	98.8	89.8	46.3
AGS187	7.35bc	5.67bcdef	–	8.89	10.58b	7.88bc	8.48c	8.14	80.8	80.6	52.4
AGS188	10.15a	4.64cdef	13.52abcd	6.84	11.88ab	6.79c	10.89ab	9.24	91.8	82.8	66.2
AGS189	8.28b	6.15bcde	8.71d	7.92	10.83ab	7.81bc	6.72cd	8.06	80.0	80.5	54.4
AGS190	10.28a	6.79abcd	19.15a	–	8.78c	7.22c	8.79bc	10.17	101.0	98.4	51.7
AGS191	10.25a	7.01abc	15.25abc	–	8.28c	7.34c	8.38c	9.42	93.6	98.0	46.9
Tainung 205	9.93a	7.55ab	11.46bcd	6.62	12.63a	9.96a	12.32a	10.07	100.0	79.8	64.2
Ryokkoh	8.35b	8.83a	9.70cd	11.86	12.25ab	8.89ab	8.07c	9.71	96.4	81.0	76.6
LSD (0.05)	1.17	2.41		n.s.	1.78	1.22	2.13	n.s.			

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 24. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, autumn 1983.[z]

Entry	Yield (t/ha)							Index	Days to Maturity	100-Seed Wt (g)
	AVRDC	Taichung DAIS		Tainan DAIS	Kaohsiung Dais		mean			
		Houli	Fengyuan	Peikang	Likang	Meilong				
AGS184	9.68a	–	–	–	–	–	9.68bcd	72.4	69.0	61.3
AGS185	7.60de	12.65c	11.90c	10.39c	5.79cd	6.45b	9.63cd	72.0	71.8	69.7
AGS186	8.83bc	13.65bc	12.03c	13.54a	11.08a	7.47b	11.10abc	83.0	75.0	53.6
AGS187	7.15e	11.80c	14.20bc	11.02bc	4.28e	2.46c	8.49d	63.5	69.7	62.9
AGS188	8.28cd	14.90abc	15.63bc	12.40abc	9.66ab	8.42b	11.55ab	86.4	72.3	73.6
AGS189	8.68bc	17.58ab	16.95b	12.29abc	4.51de	6.90b	11.15abc	83.4	74.0	55.7
AGS190	9.68a	15.38abc	14.18bc	13.85a	8.98b	7.02b	11.50ab	86.2	74.0	66.0
AGS191	9.45ab	14.55bc	17.75b	10.49bc	9.22b	7.65b	11.52ab	86.2	73.3	69.4
Tainung 205	9.80a	17.13ab	22.13a	12.94ab	10.11ab	8.11b	13.37a	100.0	70.7	80.0
Ryokkoh	9.43ab	18.83a	13.85bc	12.37abc	6.90c	10.40a	11.96ab	89.5	72.5	98.9
LSD (0.05)	0.75	3.692	3.807	2.214	1.397	1.979	2.090			

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 25. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, 1983.[z]

Entry	Yield (t/ha)				Index	Days to Maturity				100-Seed Wt (g)
	spring	summer	autumn	mean		spring	summer	autumn	mean	
AGS184	7.62	8.47	9.68	8.59b	73.8	87	90	69	81.9	52.3
AGS185	7.96	7.76	9.63	8.45b	72.6	85	76	72	77.6	61.1
AGS186	9.95	8.46	11.10	9.84ab	84.5	90	76	75	80.3	49.5
AGS187	8.14	9.07	8.47	8.57b	73.6	80	70	70	73.3	59.5
AGS188	9.24	9.53	11.55	10.11ab	86.9	83	74	72	76.4	71.2
AGS189	8.06	10.60	11.15	9.94ab	85.4	81	74	74	76.2	56.3
AGS190	10.17	7.53	11.52	9.74b	83.7	98	91	74	87.8	59.8
AGS191	9.42	7.67	11.52	9.54b	82.0	98	91	73	87.4	59.0
Tainung 205	10.07	11.48	13.37	11.64a	100.0	80	70	71	73.5	73.6
Ryokkoh	9.71	8.19	11.96	9.95ab	85.5	81	76	73	76.5	90.1
LSD (0.05)	n.s.	1.795	2.090	1.678						

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 26. Locations, planting dates and harvesting dates of the vegetable soybean regional yield trials, Taiwan 1984.

Location	Season	Cooperating Station	Date Planted	Date Harvested
AVRDC	Spring	AVRDC	Jan. 27	May 1 – 14
Houli	"	Taichung DAIS	Mar. 29	July 16 – 16
Fengyuan	"	"	Mar. 25	May 26 – June 11
Peikang	"	Tainan DAIS	Feb. 10	May 11 – 17
Kaoshu	"	Kaohsiung DAIS	Feb. 13	May3 – 5
Yenpu	"	"	Jan. 26	Apr. 13 – May 4
AVRDC	Summer	AVRDC	July 13	Oct. 12 – 31
Houli	"	Taichung DAIS	July 22	Oct. 4 – 16
Fengyuan	"	"	July 7	Sept.20 – Oct. 6
Peikang	"	Tainan DAIS	June 22	Aug. 30 – Sept.17
AVRDC	Autumn	AVRDC	Sept.13	Nov. 20 – Nov. 29
Peikang	"	Tainan DAIS	Sept.18	Nov. 21 – Nov. 23
Kaoshu	"	Kaohsiung DAIS	Oct. 5	

Table 27. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, spring 1984.[z]

Entry	Yield (t/ha)							Index	Days to Maturity	100-Seed Wt (g)
	AVRDC	Tainan DAIS	Taichung DAIS		Kaohsiung DAIS		mean			
		Peikang	Fengyuan	Houli	Yenpu	Kaoshu				
AGS184	13.4a	11.3d	16.3a	6.3d	8.8c	8.3d	10.73bc	89	94.5	55.1
AGS185	5.9e	10.1e	16.0a	11.4c	4.0e	8.7cd	9.35c	77	90.5	60.9
AGS186	12.1abc	14.4a	17.2a	16.4a	10.8b	12.4a	13.88a	115	98.0	56.3
AGS187	10.7bcd	12.6bc	10.6b	10.3c	11.5ab	9.6bcd	10.88bc	90	93.0	65.5
AGS188	12.0abc	12.7b	14.3a	11.1c	11.9a	10.5abcd	12.10ab	100	95.7	73.4
AGS189	8.5d	11.9cd	10.1b	12.6bc	8.8c	11.9ab	10.63bc	88	92.8	61.8
AGS190	12.6ab	12.9b	15.0a	–	5.7d	11.2abc	11.48abc	95	95.4	63.9
AGS191	9.8cd	12.1 bcd	14.3a	–	5.4d	10.2abcd	10.36bc	86	95.0	64.6
Tainung 205	12.1abc	12.8 b	14.1a	12.1bc	9.7c	11.7ab	12.08ab	100	92.0	71.5
Ryokkoh	10.6bcd	11.4d	14.7a	14.0b	11.4ab	9.8abcd	11.98abc	99	92.8	87.4
LSD (0.05)	2.186	0.788	2.830	2.319	0.885	2.424	2.320			

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 28. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, summer 1984.[z]

Entry	Yield (t/ha)					Index	Days to Maturity	100-Seed Wt (g)
	AVRDC	Tainan DAIS	Taichung DAIS		mean			
		Peikang	Fengyuan	Houli				
AGS184	13.8b	11.3cd	22.8a	10.3	14.6	107	94.5	47.5
AGS185	11.0de	14.8a	14.8bcd	11.7	13.1	96	81.8	56.3
AGS186	12.0cd	10.9d	16.5bc	13.3	13.2	97	85.5	47.8
AGS187	9.9e	11.3cd	13.0cd	9.8	10.8	79	78.0	56.4
AGS188	13.4b	10.2d	11.3d	13.9	12.2	90	78.5	68.5
AGS189	11.2d	12.6bc	12.8cd	11.5	12.1	89	77.3	63.9
AGS190	13.0bc	10.1d	16.2bc	11.1	12.6	93	92.0	55.0
AGS191	15.2a	10.1d	17.4b	11.6	13.6	100	92.0	54.8
Tainung 205	13.6b	13.5ab	14.6bcd	12.6	13.6	100	82.0	70.0
Ryokkoh	10.7de	10.6d	11.8d	11.4	11.1	82	78.0	72.5
LSD (0.05)	1.248	1.445	3.387	n.s.	n.s.			

[z]Mean separatio within columns by Duncan's multiple range test at 5% probability level.

Table 29. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials, autumn 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	100-Seed Wt (g)
	AVRDC	Tainan DAIS	Kaohsiung DAIS	mean			
		Peikang	Kaohsu				
AGS184	7.6b	5.1c	7.5bc	6.7ab	86	70.0	54.7
AGS185	7.4b	5.6bc	9.0a	7.3ab	94	68.3	57.3
AGS186	7.8b	8.2a	8.9a	8.3a	106	75.0	53.0
AGS187	6.0c	4.5c	7.3c	5.9c	76	68.0	57.7
AGS188	8.0b	6.1bc	9.2a	7.8ab	100	72.3	63.7
AGS189	7.8b	6.2bc	8.6ab	7.5ab	96	69.7	52.7
AGS190	9.5a	6.0bc	8.7a	8.1ab	104	73.3	58.7
AGS191	9.0a	8.4a	8.6a	8.7a	112	72.3	57.3
Tainung 205	7.8b	7.2ab	8.3abc	7.8ab	100	68.0	67.3
Ryokkoh	7.8b	5.7bc	9.0a	7.5ab	96	69.0	74.3
LSD (0.05)	0.923	1.549	1.054	1.243		4.552	7.747
LSD (0.01)	1.246	2.091	n.s.	n.s.		n.s.	10.612

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 30. Yields and horticultural characters of entries in the Taiwan vegetable soybean regional yield trials in 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	100-Seed Wt (g)
	spring	summer	autumn	mean			
AGS184	10.7bc	14.6	6.7ab	10.7	96	86.3	52.4
AGS185	9.4c	13.1	7.3ab	9.9	88	80.2	58.2
AGS186	13.9a	13.2	8.3a	11.8	105	86.2	52.4
AGS187	10.9bc	10.8	5.9c	9.2	82	79.7	59.9
AGS188	12.1ab	12.2	7.8ab	10.7	96	82.2	68.5
AGS189	10.6bc	12.1	7.5ab	10.1	90	79.9	59.5
AGS190	11.5abc	12.6	8.1ab	10.7	96	86.9	59.2
AGS191	10.4bc	13.6	8.7a	10.9	97	86.4	58.9
Tainung 205	12.1ab	13.6	7.8ab	11.2	100	80.7	69.6
Ryokkoh	12.0abc	11.1	7.5ab	10.2	91	79.9	78.1

[z]Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 31. Yields and agronomic characters of entries in the Taiwan soybean regional yield trials, spring 1984.[z]

Entry	Yield (t/ha)				Index	Days to Maturity	100-Seed Wt (g)	Protein (%)	Oil (%)
	AVRDC	Kaohsiung DAIS		mean					
		Chiyang	Yenpu						
AGS129	3.62abc	1.94	2.61	2.72	88	115	20.0	39.2	23.6
AGS157	3.04d	2.37	2.58	2.66	86	120	20.2	39.4	22.7
AGS133	3.55bc	2.37	2.59	2.84	92	111	22.8	43.4	20.6
TARI4	3.71ab	2.36	2.67	2.91	94	117	22.4	41.5	22.4
TARI5	3.50bc	2.33	2.55	2.79	91	120	23.4	46.6	19.5
Hualien 69-7	3.60abc	2.42	2.50	2.84	92	110	21.3	43.7	21.7
Hualien 70-40	3.49bc	2.34	2.56	2.80	91	117	22.9	41.6	23.6
RM178	3.40c	2.27	2.49	2.72	88	109	19.8	43.8	22.8
KS1264	3.66ab	2.47	2.70	2.94	95	116	26.1	44.0	20.3
KS1266	3.83a	2.15	2.30	2.76	90	113	22.3	41.2	20.6
KS8	3.83a	2.62	2.80	3.08	100	117	27.5	42.6	20.5
R50	3.18d	2.19	2.40	2.59	84	119	19.0	44.2	21.9
LSD (0.05)	0.224	0.210	0.224						

[z]Date sown: AVRDC, Jan. 26; Chiyang, Jan. 28; Yenpu, Jan. 26. Date harvested: AVRDC, May 22 to June 4; Chiyang, June 13 to 25; Yenpu, June 12 to 23. Mean separation within columns by Duncan's multiple range test at 5% probability level.

District trial. The soybean district trial (SBDT) conducted in AVRDC and in Kaohsiung DAIS, used four improved lines. These lines were tested in AVRDC against the local checks, KS8 and AGS58, which performed well in the 1983 SBDT. In the four regions of Kaohsiung DAIS, the same lines were tested against KS8 and KS955.

In the spring trial at AVRDC, the check AGS58 was judged the best, There were no significant differences in yield among all the other lines (Table 33). In the Kaohsiung DAIS area, KS8 with an average yield of 2.61 t/ha, was considered the best vielder (Table 34). In the summer trial at AVRDC, all the test lines performed better in terms of yield than the local checks, with AGS 129 yielding 52% higher than the check (Table 35).

In summer 1984, AGS66 was planted in 20 ha at Tungshih and Yichu where it gave an average yield of 3.4 t/ha which was 1 t/ha higher than that of the local cultivar H15. Thus, in autumn 1984 PDAF provided the Yichu farmers with 1200 kg of AGS56 seeds for the 1985 spring planting.

Table 32. Yields and agronomic characters of entries in the Taiwan soybean regional yield trial in AVRDC, summer 1984.[z]

Entry	Yield (t/ha)	Index	Days to Maturity	100-seed Wt(g)	Protein (%)	Oil (%)
AGS129	3.38a	127	100	17.2	41.2	23.3
AGS157	2.33g	87	107	16.9	41.7	22.0
AGS133	2.38ef	89	92	15.8	42.5	21.6
TARI4	2.92b	109	95	17.0	43.7	22.0
TARI5	2.86bc	107	97	17.7	44.1	21.4
Hualien 69-7	2.50efg	94	92	19.3	42.9	22.2
Hualien 70-40	2.76bcd	103	98	16.9	43.6	22.5
RM178	2.45efg	92	95	18.2	43.0	22.5
KS1264	2.78bcd	104	98	20.1	45.8	19.9
KS1266	2.58def	97	97	17.8	42.3	21.6
KS8	2.67cde	100	103	22.6	45.5	19.7
R50	2.68cde	100	97	16.7	44.6	20.8
LSD (0.05)	0.215		2.705	1.192	1.806	0.993

[z]Date sown: July 12, 1984; date harvested: Oct. 9 to 17, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 33. Yields and agronomic characters of entries in the Taiwan soybean district trial at AVRDC, spring 1984.[z]

Entry	Yield (t/ha)	Days to Maturity	100-Seed Wt(g)	Protein (%)	Oil (%)
AGS129	3.10b	125	24.9	39.88	23.52
KS1058	3.17b	124	27.8	40.52	21.28
TARI3	3.21b	123	28.4	45.56	19.92
Hualien 76-56	3.17b	125	35.9	44.95	20.37
KS8	3.25b	14	29.2	40.41	19.66
AGS58	3.42a	124	28.1	40.13	20.10
LSD (0.05)	0.148	n.s.	2.058		

[z]Date sown: Jan. 26, 1984; date harvested: May 29 to June 1, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Table 34. Yields and agronomic characters of entries in the Taiwan soybean district trials, at Kaohsiung DAIS, spring 1984.[z]

Entry	Yield (t/ha)					Index	Days to Maturity	100-Seed Wt (g)
	Kaohsiung DAIS				mean			
	Kaohsu	Chiyang	Wanlong	Yenpu				
AGS129	1.96	1.26	2.55	3.20	2.24	86	110	20.3
KS1058	2.22	1.51	3.01	2.93	2.42	93	110	23.4
TARI3	1.83	1.23	3.24	2.93	2.31	89	116	23.5
Hualien76-56	2.12	1.60	2.93	2.87	2.38	91	114	20.7
KS8	2.61	1.49	3.21	3.11	2.61	100	109	30.1
KS955	2.26	1.53	2.91	3.06	2.44	94	110	22.4
LSD (0.05)	0.209	n.s.	n.s.	0.119				

[z]Date sown: Kaohsu, Feb. 13, Chiyang, Jan 28; Wanlong, Jan. 30; Yenpu, Jan. 26. Date harvested: Kaohsu, June 2 to 6; Chiyang, May 17 to 21; Wanlong, May 16 to 21; Yenpu, May 14 to 17.

Table 35. Yields and agronomic characters of entries in the Taiwan soybean district trial at AVRDC, summer 1984.[z]

Entry	Yield (t/ha)	Index	Days to Maturity	100-Seed Wt (g)	Protein (%)	Oil (%)
AGS129	3.49a	152	99	17.7	41.7	22.8
KS1058	2.69b	117	96	19.6	40.8	21.8
TARI3	2.48bc	108	98	18.8	43.3	22.1
Hualien 76-56	2.49bc	108	98	19.9	42.9	20.9
AGS58	2.30c	100	98	18.3	42.0	20.9
KS8	2.30c	100	102	22.3	44.7	19.4
LSD (0.05)	0.253		n.s.	1.158	n.s.	n.s.

[z]Date sown: July 13, 1984; date harvested: Oct. 16 to 22, 1984. Mean separation within columns by Duncan's multiple range test at 5% probability level.

Genetic Resources and Seed Unit

The Status of the AVRDC Germplasm Collection

The germplasm collection maintained at AVRDC's Genetic Resources Unit is summarized in Table 1. The status of germplasm characterization is summarized in Table 2.

Table 1 AVRDC germplasm collection in 1984.

Crop	Accessions	Missing	Available	Temporary Numbered Accessions	Suspected Duplicates
AVRDC Mandate Crops					
Soybean	10,544	1,180[z]	9,364	1,786	2,111 (9,034)[y]
Mungbean	5,112	165	4,944[x]	152	985 (5,112)
Tomato	5,350	138	5,212	91	40 (4,743)
Sweet potato	1,200	31	1,180	0	9 (1,200)
Chinese cabbage	822	42	780	14	–
Total	23,028	1,556	21,477	2,043	3,145 (20,089)
Other Crops					
Amaranth	86				
Adzukibean	125				
Rice bean	72				
Black gram	158				
Total	441				

[z]Includes 260 accessions which had only one to four seeds each that failed to germinate when regenerated in the greenhouse in 1983. [y]Figures in parentheses indicate the total number of accessions from which the suspected duplicates were counted. [x]Six accessions are also included in the *Vigna mungo* collection.

Table 2. Status of germplasm characterization.

Crop	Status
Tomato	4,708 accessions completed with nine characters; other accessions and characters to be added.
Sweet potato	Above-ground vegetative characters completed; flower characters completed for those that flowered; root characters to be done.
Chinese cabbage	23 accessions completed; 130 with vegetative characters and 40 with reproductive characters.
Mungbean	First half of the collection completed with 35 characters; second half with 18 characters (see "Characterization and Conservation of the World Mungbean Collection").
Soybean	Non-USDA accessions (2,672 accessions) completed (see Soybean Breeder's Report).
Black gram	Completed.

Germplasm Seed Inventory and Regeneration

A total of 28,620 seed lots were weighed. A summary of the seed stock is shown in Table 3. The 202 accessions of soybean with less than 30 g of seeds, 177 accessions of mungbean with less than 50 g, and 41 accessions of tomato with less than 5 g were regenerated immediately in the fall.

A summary of the germplasm planted in 1984 is shown in Table 4. In the coming year, accessions with poor germination will be identified for regeneration. This is important in order to avoid loss of within-accession variants and to prevent unwanted mutation. Inventory data will be computerized to include date of regeneration, regeneration cycle, seed stock, store position, seed germination, seed moisture, seed monitoring, test results, etc. This will avoid the depletion of stock to a dangerous level, low seed viability, and excessive amount of seed in store.

Table 3. A summary of germplasm seed inventory in 1984.

Soybean		Mungbean		Tomato		C.Cabbage	
Wt (g)	No. of Acc.	Wt (g)	No. of Acc.	Wt (g)	No. of Acc.	Wt (g)	No. of Acc.
<30	234	<20	30	<5	41	<1	149
30-100	182	20-50	147	5-15	672	1-5	114
100-200	838	50-100	183	15-30	1818	5-10	134
200-300	2780	100-200	1263	30-50	1702	10-50	106
300-450	4146	200-350	2127	50-70	345	50-100	27
>450	1184	>350	1197	70-100	282	100-500	55
	1180[z]		165[z]	>100	320	>500	195
					138[z]		42[z]
Total	10544		5112		5318		822

[z]Missing accessions.

Table 4. Germplasm planted in 1984.

Crop	Spring		Summer		Fall		Total	
	acc.	area (ha)	acc.	area (ha)	acc.	area (ha)	acc.	area (ha)
Soybean	2897[z]	0.70	–	–	2897[z]	0.70	5794	1.40
	–	–	–	–	164	0.10	164	0.10
Mungbean	7640[y]	2.10	–	–	3750[y]	1.95	11390	4.05
Tomato	–	–	–	–	38	0.10	38	0.10
C. cabbage	52[x]	0.20	86[x]	0.40	127[x]	0.50	265	1.10
	–	–	–	–	84[w]	0.50	84	0.50
S. potato	1370	1.80	–	–	1200	1.60	2570	3.40
Rice bean	–	–	27	pots	–	–	27	–
Total	11959	4.80	113	0.40	8260	5.45	20332	10.65

[z]Letter of Agreement: PR 3/11 IBPGR Information-Characterization, Documentation and Conservation of Soybean Collection by the breeder. [y]Letter of Agreement: PR 3/11 IBPGR Information-Characterization and Conservation of World Mungbean Collection. [x]Letter of Agreement: PR 3/11 IBPGR Training-IBPGR Internship. [w]Letter of Agreement: PR 3/11 IBPGR Crucifers-Multiplication and Characterization of Chinese Cabbage Germplasm (Phase II).

Seed Distribution

GRSU continued to supply germplasm materials to scientists at AVRDC and elsewhere, provide plant quarantine services, and ship seeds and plant materials to various countries (Table 5). Of the 27,357 items shipped out, most were breeding lines and improved lines for international testing (Table 6). A total of 6,336 lines were issued to AVRDC scientists (Table 7). The distribution of soybean, mungbean, tomato, Chinese cabbage, and sweet potato between 1973 and 1984 is summarized in Table 8.

In order to improve our services, as well as increase cost efficiency, questionnaires are being sent to our cooperators to evaluate our packaging system and to understand their quarantine requirements more. Some of the questionnaires have already been received at GRSU.

Table 5. External seed distribution in 1984 (germplasm and breeding lines).

Country	Seed Packet		Total
	5 AVRDC crops	other crops	
Indonesia	2,527	16	2,543
Philippines	2,376	13	2,389
Pakistan	1,392	25	1,417
USA	1,281	100	1,381
Thailand	1,255	8	1,263
India	1,213	13	1,226
Malaysia	696	43	739
Korea	572	61	633
Taiwan	497	11	508
South Africa	502	0	502
Others[z]	8,261	159	8,420
Total (107)	20,572	449	21,021

[z]Includes 97 countries and territories:
Anguilla Islands, Antigua, Argentina, Australia, Bahamas, Bangladesh, Barbados, Belgium, Belize, Bolivia, Botswana, Brazil, Brunei, Burma, Cambodia, Cameroon, Canada, Caroline Islands, China (Mainland), Colombia, Comoros, Congo, Cook Islands, Costa Rica, Cyprus, Denmark, Dominican Rep., Egypt, Ellice Islands, El Salvador, England, Ethiopia, Fiji Islands, France, Gambia, Ghana, Guadeloupe, Guam, Guatemala, Guyana, Haiti, Holland, Honduras, Iran, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Lesotho, Liberia, Malawi, Mariana Islands, Mauritius, Martinique Islands, Mexico, Morocco, Nepal, New Zealand, Nicaragua, Nigeria, Oman, Panama, Papua New Guinea, Paraguay, Peru, Puerto Rico, Qatar, Reunion, Samoa (W), Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Solomon Islands, Sri Lanka, St. Kitts & Nevis, St. Lucia, Sudan, Surinamie, Swaziland, Switzerland, Tahiti, Tanzania, Trinidad & Tobago, Tunisienne, Turkey, Tuvalu, Upper Volta, Uruguay, Venezuela, Virgin Islands, Yemen, Zambia and Zimbabwe

Table 6. Seeds distributed in 1984.

Crop Name	Seed Packet		Total
	internal	external	
Soybean	2,736	7,254	9,990
Mungbean	2,287	3,665	5,952
Tomato	426	7,052	7,478
Chinese cabbage	400	1,769	2,169
Sweet potato	486	832	1,318
Amaranth	0	86	86
Winged bean	0	31	31
Black gram	0	25	25
Others	1	307	308
Total	6,336	21,021	27,357

Table 7. Internal seed distribution in 1984 (germplasm materials only)[z].

Department	SB	MB	CC	TT	SP	Others	Total
Plant Breeding	259	1126	16	19	2	0	1,422
Entomology	2308	1068	246	27	484	0	4,133
Pathology	153	93	124	231	0	1	602
Physiology	0	0	3	91	0	0	94
Soil Microbiology	16	0	0	0	0	0	16
Others[y]	0	0	11	58	0	0	69
Total	2736	2287	400	426	486	1	6,336

[z]SB = soybean, MB = mungbean, CC = Chinese cabbage, TT = tomato; SP = sweet potato. [y]Including Soil Science, Crop Management, Training and Development.

Table 8. Summary of external seed distribution by year and crop from 1973 to 1984.

Year	Soybean	Mungbean	Tomato	Chinese Cabbage	Sweet Potato	Others	Total
1973-1976	10,860	7,220	4,365	631	769	5,030	28,875 (77)[z]
1977	4,512	4,585	1,954	706	162	1,977	13,896 (62)
1978	6,555	6,245	6,290	898	222	452	20,662 (77)
1979	4,423	4,324	3,145	1,199	326	1,271	14,688 (81)
1980	6,604	7,319	2,517	718	403	353	17,968 (84)
1981	4,537	2,406	3,435	1,327	619	378	12,702 (77)
1982	6,547	9,853	7,091	2,140	466	517	26,604 (102)
1983	21,555	6,264	2,950	1,996	1,180	737	34,682 (97)
1984	7,254	3,665	7,052	1,769	832	449	21,021 (107)
Total	72,847	51,881	38,843	11,384	4,979	11,164	191,098 (156)

[z]Figures in parentheses refer to number of countries.

New Building Construction and Equipment

In order to expand our activities both as a gene bank and a seed technology laboratory for research and training, a proposal was submitted to the Council for Agricultural Planning and Development (CAPD) for the construction of a new building. It was approved for funding on January 21, 1983. Chen, Lee and Associates was chosen to design the building. Because of the high cost estimates submitted, modifications were made. The final design was reviewed and approved by CAPD on March 12, 1984, electrical utilities installed, and construction begun on June 22, 1984. Currently it is nearing completion.

The capital cost was funded mainly by the Council of Agricultural (COA, formerly CAPD). Other donors are the German Agency for Technical Cooperation, Ltd. (GTZ) and the International Board for Plant Genetic Resources (IBPGR). The rooms, their surface areas, and dimensions are shown in Table 9.

Table 9. Rooms, surface areas, and dimensions of the GHSU building.

Facility	Surface Area(m^2)	Dimension(m) L × W × H
Store:		
(1) Long-term store, -20°C preferably frost-free	35.07	6.4 × 2.74 × 2.13 (2sets)
(2) Medium-term store, 2-5°C, 40% RH	90.77	6.4 × 2.74 × 2.13 (3sets) 3.6 × 3.6 × 2.13 (2sets) 2.95 × 4.15 × 2.13 (1set)
(3) Short-term store, 15°C, 40% RH	104.47	11.4 × 9.14 × 2.44
(4) Tuber store, 15°C, 80-95% RH	35.51	7.77 × 4.57 × 2.44
Supporting facilities:		
(5) Packaging room, 20°C, 40% RH	41.13	9.0 × 4.57 × 2.44
(6) Drying room I, 20°C, 40% RH	15.02	5.48 × 2.74 × 2.44
(7) Drying room II, 15°C, 15% RH	5.01	2.74 × 1.83 × 2.44
(8) Seed handling room	120.00	12 × 10 × 3.43
(9) Wet lab. (for cleaning tomato seed)	25.65	5.7 × 4.5 × 3.43
(10) Drying yard	174.00	14.5 × 12
(11) General lab. (for seed quality, physiology, biosystematic, etc.)	79.20	9.9 × 8.0 × 3.43
(12) Pathology laboratory	16.00	4.0 × 4.0 × 3.43
(13) Tissue culture lab.	21.00	6.0 × 3.5 × 3.43
(14) Germination room	14.00	4.0 × 3.5 × 3.43
(15) Preparation room	16.80	4.8 × 3.5 × 3.43
(16) Classroom	20.00	5.0 × 4.0 × 2.95
(17) Computer room	10.88	3.75 × 2.9 × 3.43
(18) Offices (3)	52.57	5.0 × 3.8 × 3.43 (2) 3.9 × 3.8 × 3.43

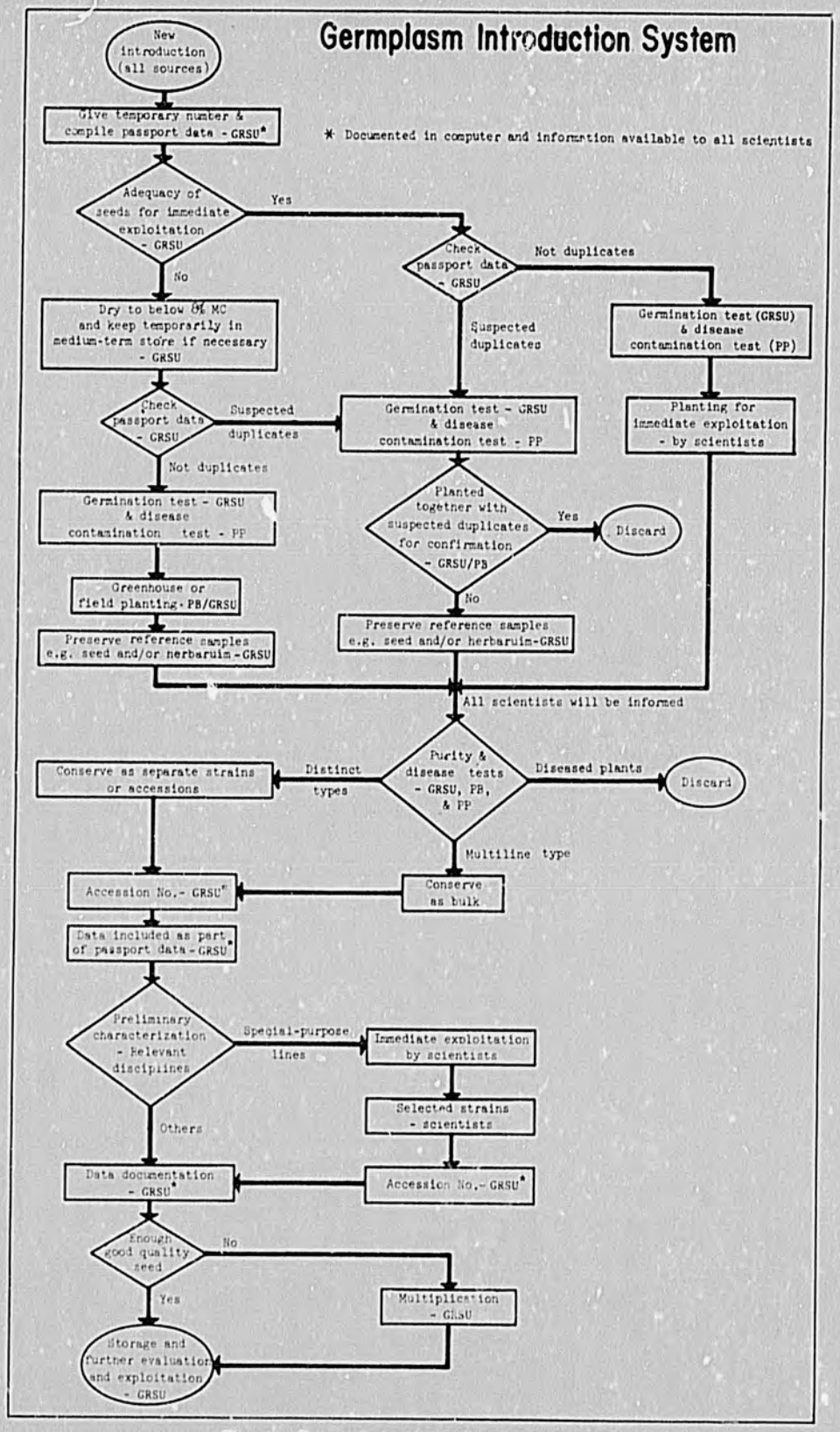


Fig. 1. Germplasm introduction system.

The objectives of the Genetic Resources and Seed Unit (GRSU) were reviewed, priorities set, and recommendations submitted to the Director General for consideration. One of the recommendations is a new schemes for germplasm introduction (Fig. 1). This will serve to centralize germplasm work. The Ito's two-step seed-storage system will be adopted. The type of collections of our germplasm materials will be as shown in Table 10.

Table 10. The AVRDC germplasm collections.

Crop	Type of Collection[z]
Soybean	Active collection
Mungbean	Active collection and base collection
Tomato	Active collection
Chinese cabbage	Active collection
Sweet potato	Active collection and base collection for Asian and Pacific materials
Others	Active collection

[z]Type of collections: base collection-permanent collection and not for distribution; active collection-collection suitable for distribution; working collection-temporary collection when variants may be discarded anytime.

AVRDC / IBPGR Joint Projects

I. Multiplication of AVRDC Chinese Cabbage Collection for Long-Term Storage at NVRS—Phase II.

Introduction

The letter of agreement entitled PR 3/11 IBPGR Crucifers dated December 7, 1982 covers the period from January 1983 to December 1984. Its objective is to continue seed multiplication and characterization until all the open-pollinated materials are deposited in the cruciferous "base" store at the National Vegetable Research Station (NVRS), Wellesbourne, United Kingdom.

Accessions to NVRS

The number of accessions sent to NVRS is summarized in Table 11. In the 1984-85 season, 84 accessions were planted; but depending on the accuracy of vernalization, some accessions did not flower.

Table 11. Summary of AVRDC Chinese cabbage collection by breeding type and number sent to NVRS.

Type	No. of Acc.	No. of Acc. Sent to NVRS				Remainder
		1982	1983	1984	1985 (estimated)	
OP	287	26	47	55	63	96
OP?	87	40	21	7	7	12
F1	368	3	–	–	–	365
F1?	7	4	2	1	–	0
F2	1	–	1	–	–	0
Inbred	72	2	5	–	–	65
Not yet accessioned	14	–	–	–	14	0
Total	836	75	76	63	84	538

At the end of phase I and phase II, 188 accessions remain to be multiplied for NVRS (Table 12). Of these, 36 which has a germination rate greater than 95% (according to ISTA rules), can be obtained from seed companies. Seeds sent to NVRS in 1984 had germination rates of 99.44%, on the average. NVRS is using 85% rate as the regeneration standard. Twenty-nine accessions did not have a sufficient number of plants from previous multiplications and, therefore, were to be multiplied again from original seeds or other more advanced regeneration cycle seeds. Seeds of the two multiplications can then be combined at NVRS.

The characterization of Chinese cabbage can be divided into two parts: vegetative characters and reproductive characters. Vegetative characters consist of the seedlings and nonreproductive growth-stage characters. Reproductive characters consist of flowering and seed characters.

Multiplication

The 84 accessions under multiplication in the 1984-85 season are shown in Table 13. Bolting in the field was quite irregular because of the warm weather in November and the first two weeks of December. Some of the plants were devernalized, and we, therefore, expected to discontinue some of the accessions from the multiplication program.

The six accessions out of sixty with off-type plants are indicated in Table 14.

Table 12. Summary of the AVRDC Chinese cabbage regeneration for long-term storage at NVRS at the end of phase I and II.

No. of accessions under multiplication in 1984/85 season	84
No. of accessions awaiting multiplication and further multiplication	40
No. of accessions already at Tsukuba which may have to be duplicated at NVRS	28
No. of accessions obtained from seed companies	36
Total	188

Table 13. Accessions under multiplication in the 1984-85 season.

Species	No. of Accession
1. *B. campestris* subsp. *pekinensis*	15
2. *B. campestris* subsp. *chinensis*	25
3. *B. campestris* subsp. *parachinensis*	12
4. *B. campestris* subsp. *rapa*	24
5. *B. campestris* subsp. *japonica*	3
6. *B. campestris* (?)	1
7. *B. juncea*	4
Total	84

Table 14. Six accessions with off-types.

Acc. No.	Name	Total Plant No.	No. of Discarded Off-Types	Off-Types (%)
6	New King	169	53	31.36
195	Crispy Choy	185	1	0.54
582	60 days Choy Sum	128	23	17.97
583	80 days Choy Sum	179	28	15.64
607	80 days Rape	183	1	0.55
609	40 days Choy Sum	186	1	0.54

II. Soybean Characterization

Introduction

The letter of agreement is entitled PR 3/11 IBPGR Information. Its objective is the characterization, documentation, and distribution of soybean accessions which did not originate from the United States Department of Agriculture (USDA), and the deposition of these in the designated world collections, i.e., National Seed Storage Laboratory (NSSL), Colorado, with small samples to the National Institute of Agrobiological Resources (NIAR), Tsukuba, Japan.

Progress

Of the 10,524 accessions in our collection, 7,592 are in the USDA catalogs. The remaining 2,672 accessions were sorted out and planted before they were handed over to the breeder for characterization. A summary of the different types in the 2,672 accessions is shown in Table 15. It is less complicated than mungbean. These activities were done with the cooperation of the AVRDC soybean breeder.

Table 15. Number of soybean types per accession.

Type per Accession	Frequency	Percentage
1	2,535	94.87
2	130	4.87
3	4	0.15
4	1	0.04
6	1	0.04
11	1	0.04
Total	2,672	

III. Characterization and Conservation of the World Mungbean Collection

Introduction

The letter of agreement entitled PR 3/11 IBPGR Information dated October 5, 1983 covers the period from February 1984 to January 1985. Its objective is to characterize mungbean according to the IBPGR descriptor list for *Vigna radiata* (AGP: IBPGR 80/35) and to conserve the world mungbean collection.

The Collection

There are 5,119 accessions in the mungbean collection. Out of these, 34 are suspected to be *Vigna mungo*, 2 *Vigna unguiculata*, and 165 missing accessions. No attempt is being made to renumber the misclassified accessions because they were issued for research already. The collection came from 49 countries (Table 16).

From 1973 to 1984, 51,881 mungbean germplasm samples (both accessions and breeding lines) were distributed to about 100 countries; and 44,907 accession samples were turned over to our AVRDC scientists for research (Table 17). Attempts are being made to re-acquire the missing accessions. In addition to the mungbean collection, we have other related *Vigna* collections as indicated below:

Vigna mungo	158	*Vigna umbellata*	72
Vigna angularis	125	*Vigna aconitifolia*	28

Table 16. AVRDC *Vigna radiata* collection by country of origin.

Country	No. of Acc.	Country	No. of Acc.
1. Afghanistan	285	26. Japan	3
2. Argentina	3	27. Kenya	9
3. Australia	121	28. Korea	140
4. Bangladesh	6	29. Madagascar	11
5. Brazil	5	30. Malaysia	2
6. Burma	11	31. Mexico	2
7. Canada	2	32. Netherlands	39
8. China	18	33. Nigeria	32
9. Congo	3	34. Pakistan	124
10. Cuba	1	35. Peru	4
11. Denmark	2	36. Philippines	312
12. Ecuador	1	37. South Africa	2
13. England	42	38. Senegal	1
14. Ethiopia	3	39. Somalia	1
15. France	29	40. Sri Lanka	16
16. Ghana	2	41. Suriname	1
17. Guam	3	42. Taiwan	41
18. Guatemala	8	43. Tanzania	1
19. Guyana	1	44. Thailand	235
20. Hong Kong	20	45. Trinidad	1
21. India	2,558	46. Turkey	25
22. Indonesia	66	47. USA	150
23. Iran	628	48. USSR	4
24. Iraq	4	49. Vietnam	21
25. Ivory Coast	13	Unknown	107
Total			5,119

Table 17. Mungbean seed distribution from 1973 to 1984.

	No. of Seed Packet										Total
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
Internal	7703	3932	6908	6307	710	2709	5189	2317	6845	2287	44907
External		7220	4585	6245	4324	7319	2406	9853	6264	3665	51881
		(1973-1976)									
Total	7703	11152	11493	12552	5034	10028	7595	12170	13109	5952	96788

Progress

Presently, we have the following passport data for our mungbean collection:

(1) Accession number
(2) Name of accession
(3) Species name
(4) PI No., M No., EM No., PHLV No., CES No., UPCA No., STB No., EC No., DSU No., ML No., etc.
(5) Origin

More data, which will be supplied in magnetic tape, will be obtained from Dr. Mark Perry, IBPGR Liaison Officer for documentation.

A total of 983 suspected duplicates forming 480 duplicate groups were identified after comparing their PI No., MO No., EM No., and name (Table 18). The suspected duplicates were planted next to each other in the field for comparison.

Accessions with mixed seeds were sorted according to luster, color, size, and shape. Seeds were divided by color into yellow, light green, green, light brown, mottle blackish brown, black and red; and by luster, into dull and shiny. After sorting, a total of 7,965 entries was

obtained. The number of types per accession is shown in Table 19, and the frequency with which they occurred is shown in Table 20.

From past experience, mungbean was shown to be affected by environmental differences, i.e., seasons, soil fertility, and crop management. The "plasticity" was high. To avoid this, we characterized the whole collection or big set of accessions together in single plantings so as to remove some of the variations in environment and genetic-environment interaction. The result from each characterization will, therefore, be more comparable. In addition, a character was assessed by the same person or the same group of persons, if more that one person was needed.

Spring Planting

A total of 7,965 entries were planted from March 7 to March 9, 1984 in 7,640 1-m plots with double rows. Some variants within an accession that were less distinctive, especially the yellowish green and light brown seed types, were planted in single plots with one row

Table 18. Mungbean duplicates and duplicate groups.

No. of Accessions/ Duplicate Groups	No. of Groups	Percentage	No. of Duplicates
2	251	52.30	251
3	104	21.70	208
4	58	12.10	174
5	32	6.70	128
6	11	2.30	55
7	10	2.10	60
8	8	1.70	56
9	3	0.19	24
10	3	0.10	27
Total	480		983

Table 19. Number of types per accession in the mungbean collection.

Kind/Accession	Frequency	Percentage
1	2,507	51.000
2	1,881	38.300
3	435	8.800
4	78	1.600
5	16	0.030
6	2	0.004
Total	4,919	

Table 20. Frequency of mungbean types.

Kind	Frequency	Kind	Frequency
Green: shiny	2,848	Brown: shiny	91
dull	3,209	dull	722
shiny, mottled	84	mottled	6
dull, mottled	78	Subtotal	819
black gram hilum	4		
Subtotal	6,223	Black: shiny	17
		dull	95
Yellow: shiny	94	shiny, mottled	328
dull	147	dull, mottled	238
mottled	2	Subtotal	678
Subtotal	243	Red	2
Total			7,965

to a type. About two to three weeks after sowing, thinning was done by leaving a single plant at every 5 cm distance within the row. Standard crop-management practices were followed. However, both insecticides and fungicides were applied once a week. As a result, there was no serious insect and disease infection. Virus-infested plants were removed when there were only a few in a plot.

Harvesting commenced on May 19, 1984 at 72 days after planting. After about 1,200 accessions were harvested, a continuous rainfall destroyed the crops. The seeds started to germinate on the plants and the rest of the crop had to be discarded.

Fall Planting

The first half of the whole collection consisting of 3750 entries from accessions V1001 to V2649 plus the duplicates were planted on August 28, 1984. Each accession was planted on a two-m plot with double rows. Immediately after sowing, a section of the field with 350 plots was flooded by a typhoon and, as a result, germination was not uniform and had to be discarded. The rest of the field with 3400 entries grew vigorously and produced a good stand for characterization. Thinning and crop management were done as in the spring crop. Again the field was free of major pests and diseases. Virus-infested plants were rogued.

At AVRDC, the fall planting is the seed-production season because of the cool-dry weather at harvest. Two-meter plots were used in order to produce enough stock seeds and seeds for chemical analysis (for seed protein and starch with the Near-IR analyser). Harvesting commenced on October 24, 1984 at 56 days after planting. All the 3400 entries were harvested.

Characterization

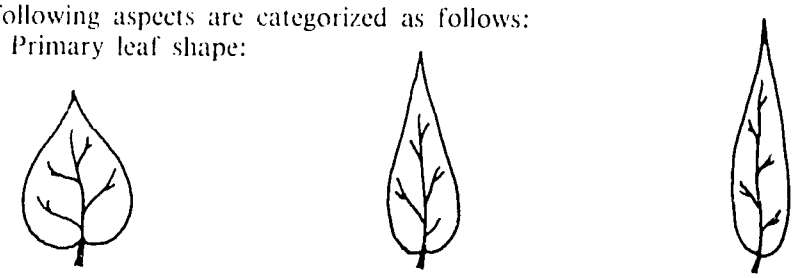
The characterization in the two seasons is summarized in Table 21. IBPGR descriptors (IBPGR/80/35) were followed as closely as possible and eleven other characters were added. In the spring season, 24 characters on 7,640 plots were made, resulting in 313,000 pieces of data. In the fall, the addition of 24 characters on 3,400 plots totaled 160,000 pieces of data.

The eleven additional characters were primary leaf length, primary leaf width, primary leaf shape, leaf vein pigmentation, leaf pubescence length, corolla color (wings), pod pubescence color, pod pubescence length, plant height at maturity, hilum color, and seed starch.

Recorded on five randomly selected plants instead of ten plants per plot were the primary leaf length (addition) and width (addition), and plant height at flowering (4.5) and maturity (addition), number of clusters per plant (4.11), pod length (3.6.6), and number of seeds per pod (7.2). The first three plants from the two ends of a row were not sampled. The averages will be used in the catalogue.

The following aspects are categorized as follows:

1. Primary leaf shape:



a. b. c.

2. Leaf vein pigmentation: green, greenish purple, purple, and dark purple
3. Leaf pubescence length: short, medium, and long
4. Corolla color (wings): light yellow and yellow
5. Pod pubescence color: white, white and brown, and brown
6. Pod pubescence length: short, medium, and long
7. Hilum color: white and black

Days to flowering and harvesting, and other qualitative characters were assessed based on the general performance of the whole plot. Number of pods per plant was counted on a normal plant selected randomly; weight of 1000 seeds, from a random sample of 1000 seeds.

The IBPGR descriptors are put into test for two seasons. The remarks on each of the characters are given in Table 22.

Examples of Some Characterization Results

The number of days to flowering for the spring and fall crops for the first 3,400 entries are shown in Figs. 2 and 3, respectively. The number of days to maturity for the spring and fall crops are in Figs. 4 and 5, respectively.

Table 21. Summary of mungbean characterization in 1984.

Measured Character	IBPGR Descriptor Code	Planting Season[z]	
Growth habit	3.1	S	
Hypocotyl color	3.3	S	F
Leaf: (1) terminal leaflet shape	3.4.1	S	
(2) pubescence-number	3.4.3	S	
(3) petiole color	3.4.5	S	
Raceme position	3.5.3		F
Flower: (1) calyx color	3.5.4	S	
(2) corolla color-standard	3.5.5	S	
Pods: (1) pod color	3.6.1		F
(2) pod pubescence-number	3.6.7	S[x]	F
(3) pod length[y]	3.6.6	S	F
Seeds: (1) color	3.7.1	S[x]	F
(2) mottling on seed	3.7.2		F
(3) surface luster	3.7.3	S[x]	F
Flower: (1) days to flowering	4.3	S	F
(2) plant height when flowering[y]	4.5	S	F
Flowering period	4.9		F[x]
Numbers of clusters[y]	4.11		F
Maturity, days	4.12	S	F
Lodging	4.14		F
Pods per plant	7.1		F
Seeds per pod[y]	7.2	S	F
1000-seed weight	7.3		F
Seed protein	11.1		F
Primary leaf: length[y]	Addition	S	F
width[y]	Addition	S	
shape	Addition	S	
Leaf: (1) pubescence-length	Addition	S	
(2) vein color	Addition	S[x]	
Flower: corolla color-wings	Addition	S	
Pod pubescence: color	Addition	S[x]	F
length	Addition	S[x]	F
Seeds: hilum color	Addition		F
Plant height at maturity[y]	Addition	S	F
Seed starch	Addition		F
Number of characters studied per season	24 (S)	24 (F)	
Total no. of recordings taken per season	313,000 (S)	160,000 (F)	

[z]Planting season: S-spring season (March to June), 7,640 entries from acc. 1001 to acc. 6112. F-fall season (August to December) 3,400 entries from acc. 1001 to acc. 2649. [y]Five readings were recorded per accession. [x]Partially characterized.

Table 22. Remarks on the IBPGR descriptors for mungbean (AGP: IBPGR/80/35)[z].

Code No.	Character	Remarks
3.1	Growth habit	Easy to characterize as given.
3.2	Growth pattern	Difficult to characterize.
3.3	Stem color below primary leaves at seedling stage	With 3 categories: green, upper green and hypocotyl purple, and all purple.
3.4.1	Terminal leaflet shape	With 2 distinct categories: lobed and a range between deltoid and ovate.
3.4.2	Terminal leaflet length	A range in an accession and affected by environment; characterized as given.
3.4.3	Leaf pubescence	With 3 categories: few, intermediate, and dense.
3.4.4	Leaf color	All almost the same; depending on environment.
3.4.5	Petiole color	With 4 categories: green, green with purple spots, greenish purple, and purple.
3.4.6	Color of petiole/leaf blade joint	Probably related to 3.4.5.
3.4.7	Color of basal petioles	Probably related to 3.4.5.
3.4.8	Petiole length	Needs further observation.
3.4.9	Leaf senescence	Needs funher observation.
3.5.1	First pod-bearing node	Needs further observation.
3.5.2	Length of peduncle	Needs further observation.
3.5.3	Raceme position	As given.
3.5.4	Calyx color	With 3 categories: green, purplish green, and greenish purple.
3.5.5	Corolla color	With 4 major categories: (1) yellow-very light yellow, light yellow, and yellow. (2) greenish yellow-very light greenish yellow, light greenish yellow, and greenish yellow. (3) yellowish green-light yellowish green and yellowish green. (4) green purplish yellow-light green purplish yellow and green purplish yellow.
3.6.1	Pod color at immature stage	Difficult to differentiate because of different stages in a plot.
3.6.2	Color of ventral suture of immature pod	Needs further observation.
3.6.3	Pod color at mature stage	With 5 categories: straw, tan, brown, brown and black and black.
3.6.4	Shape of ripe pod	Difficult and need further observation.
3.6.5	Attachment of mature pod to peduncle	Range between pendant and intermediate almost none with angle of around 90°.
3.6.6	Pod length	Measured on five random pods.
3.6.7	Pod pubescence	With 3 categories: few, intermediate and dense.
3.6.8	Constriction of pod between seeds	Needs further observation.
3.6.9	Pod curvature	Needs further observation.
3.7.1	Seed color	With 5 categories: yellow, greenish yellow, brown, brown green, and dark green.
3.7.2	Mottling on seed	As given.
3.7.3	Luster on seed surface	As given.
3.7.4	Seed shape	As given.
3.7.5	Hilum	Difficult to record.
4.2	Days to emergence	As given-on comparable samples.
4.3	Days to 50% flowering	As given.
4.4	Seedling vigor	As given-on comparable samples.
4.5	Plant height	Average of 5 randomly selected plants.
4.6	Twining tendency	Needs further observation.
4.7.1	Branch character	Needs further observation

Table 22. (Continued)

Code No.	Character	Remarks
4.7.2	Length of branch	Quite variable within an accession; needs further observation.
4.8	Leafiness	Needs further observation.
4.9	Flowering period	As given
4.10	Rate of flower drop	Needs further observation.
4.11	Number of clusters	Average of 5 randomly selected plants.
4.12	Days to 50% ripe pods	As given.
4.13	Shattering in the field	As given.
4.14	Lodging	As given.
4.15	Nodulation	As given.
7.1	Pods per plant	Average of 5 randomly selected plants.
7.2	Seeds per pod	Average of 5 randomly selected pods.
7.3	1000-seed weight	Weight of 1000 randomly selected seeds.
7.4	Yield per plant	Weight of whole plot.
7.5	Percentage of the first harvest over the total harvest	As given.
7.6	Shelling percentage	As given.

[7]For measured characters, recording on ten plants would be better than five plants. However, in mungbean, G×E variation is big and by taking only five measurements, more accessions can be assessed at a time. The data will then be more useful because we will have a bigger set of comparable data.

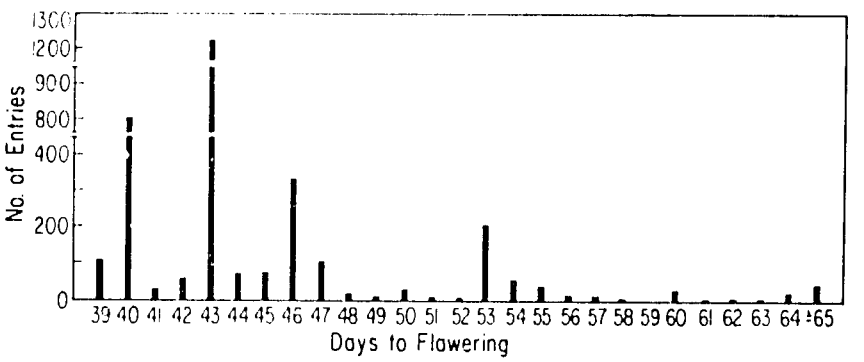


Fig. 2. Number of days to flowering of the spring crop.

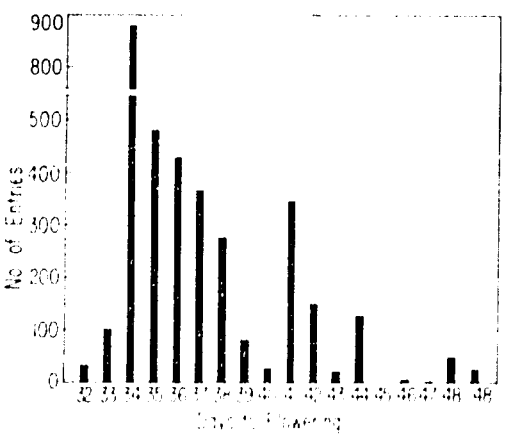


Fig. 3. Number of days to flowering of the fall crop.

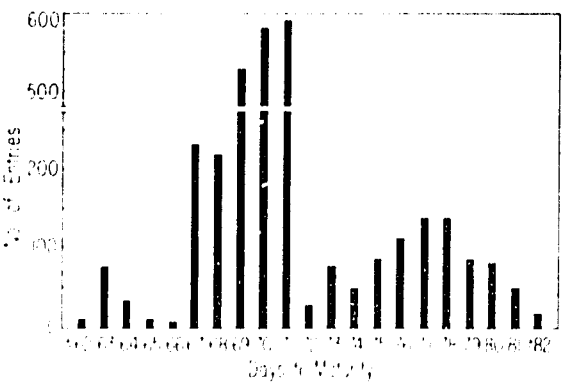


Fig. 4. Number of days to maturity of the spring crop.

It is interesting to see the bimodal distribution in days to flowering. Most of the accessions flowered around 43 days after sowing in spring and 34 days in fall, and the second peak was around 53 days after sowing in spring and 41 days in fall. The fall crop tended to flower earlier probably because of a shorter day length.

The same trend was reflected in days to maturity in spring; but in fall, the crop tended to ripen earlier and close together probably because of the start of the dry and cooler weather. The number of pods per plant in the fall season had a skewed distribution in Fig. 6. Most of the accessions had around 11 to 50 pods per plant. The 10 accessions with more than 100 pods per plant were 1200B-G (mottled), 1216B-G, 3107A-G, 1683B-BR, 2493A-G, 2493A-BL (mottled), 2513A-G, 5097B-G, 2547B-G, and 1752B-G.

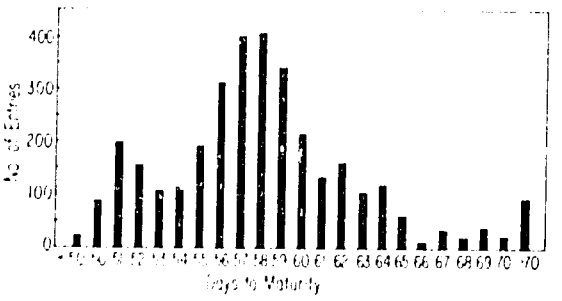


Fig. 5. (left)
Number of days to maturity of the fall crop.

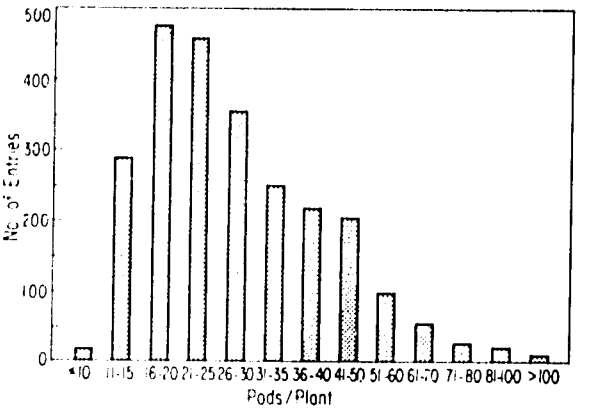


Fig. 6.
Number of pods per plant of the fall crop.

A Study of Some Morphological Characters

Fifty mungbean accessions were selected for this study. The experiment was sown directly in the field on July 26, 1984; and field management was carried out according to AVRDC recommended practices. After emergence, seven accessions (V1185, V1318, V1992, V2489, V2548, V2635, and V2640) were found to have two types of hypocotyl color. They were, therefore, divided into two types each and were studied separately.

Characterization was done according to the IBPGR descriptor list (IBPGR, 1980). In addition, primary leaf length, primary leaf width, petiolule length of terminal leaflet, terminal leaflet width, and the distance from the base of the terminal leaflet to its widest part were also measured. Leaf characters were recorded from 30 randomly selected plants.

Coefficient of variation. The mean (X), population standard deviation (SD), coefficient of variation (CV), mean of the coefficients of variation within accessions, and range of leaf characters are shown in Table 23.

The mean (X) of the CV of primary leaf length at stage 1 (character 2-a) was small, but its population CV was large. This indicated that the variation was small within accessions and large between accessions. The primary leaf length at stage 1, therefore, appeared to be the most useful one for classifying these accessions. The other characters had no difference between population CV and mean of CV.

Correlation. The correlation coefficients of leaf characters are shown in Table 24. Correlations between petiole length, petiolule length of terminal leaflet, terminal leaflet length, terminal leaflet width, and the distance from base of the terminal leaflet to its widest part were highly significant. This meant that size factor might be involved.

Primary leaf length at stage 1 and stage 2 and primary leaf width at stage 1 and stage 2 were also highly correlated. However, correlations between measurements for the two stages

Table 23. Mean, population standard deviation, coefficient of variation, mean of the coefficients of variation within accessions, and range of the nine quantitative characters studied (mungbean).

Character	X	SD	CV	Mean[z] of CV	Range
Primary leaf length at stage 1[y] (2-a)[x]	4.95	1.52	30.84	10.91	2.42- 7.42
Primary leaf length at stage 2[w] (2-b)	5.59	0.70	12.51	11.91	2.80- 6.68
Primary leaf width at stage 1 (3-a)	1.75	0.22	12.59	11.98	1.30- 2.48
Primary leaf width at stage 2 (3-b)	-2.06	0.28	13.59	12.57	1.44- 2.79
Petiole length (4)	14.96	2.25	15.03	15.97	5.64-22.10
Petiolule length of terminal leaflet (5)	3.15	0.48	15.27	15.52	1.89- 4.22
Terminal leaflet length (6)	9.59	1.34	13.97	14.13	5.68-12.92
Terminal leaflet width (7)	7.41	1.07	14.45	14.37	3.99-10.24
The distance from the base of the terminal leaflet to its widost part (8)	3.21	0.49	15.27	15.36	2.02- 4.20

[z]Mean of the coefficients of variation (CV) was calculated from the CVs of the 57 entries with about 30 samples per accession. [y]Stage 1-when the primary leaves just matured and the first trifoliate leaf appeared. [x]Character code used in the study. [w]Stage 2-when the leaf at the fourth node matured.

Table 24. Correlation coefficients of leaf characters[z] (mungbean).

	4	5	6	7	8	2-b	3-b	2-a	3-a
4	1.00	0.91 **	0.91 **	0.90 **	0.88 **	0.84 **	0.81 **	0.56 **	0.53 **
5		1.00	0.96 **	0.94 **	0.94 **	0.92 **	0.88 **	0.62 **	0.60 **
6			1.00	0.98 **	0.98 **	0.91 **	0.91 **	0.63 **	0.65 **
7				1.00	0.94 **	0.91 **	0.92 **	0.67 **	0.70 **
8					1.00	0.87 **	0.86 **	0.55 **	0.57 **
2-b						1.00	0.96 **	0.73 **	0.71 **
3-b							1.00	0.69 **	0.78 **
2-a								1.00	0.89 **
3-a									1.00

[z]Symbols: ** = significant at the % level. 2-a = primary leaf length at stage 1; 2-b = primary leaf length at stage 2; 3-a = primary leaf width at stage 1; 3-b = primary leaf width at stage 2; 4 = petiole length, 5 = petiolule length of terminal leaflet; 6 = terminal leaflet length; 7 = terminal leaflet width; 8 = distance from the base of the terminal leaflet to its widest part.

were relatively smaller. This could be due to the fact that measurements for the two stages were from different leaves. If characters 2-a and 2-b, and characters 3-a and 3-b were measured from the same leaves, the correlation could be higher.

Geographical distribution in relation to morphotypes. The geographical distribution of the accessions was plotted on the pictorialized scatter diagram (Fig. 7) with the following character hypocotyl color, pod color, seed color, and seed luster. Materials from Afghanistan and Iran had wider variations in petiole length. Other entries tended to group together according to their country of origin.

All the breeding lines had green hypocotyl color. There were no definite groupings in seed color and luster. Seed color and luster had more than one type in some accessions. These may be due to the following reasons:

(1) These accessions may still be segregating due to previous cross-pollination.
(2) These accessions may have a higher level of out-pollination which causes interbreeding and segregation.
(3) These accessions may be mechanically mixed.
(4) These accessions may lack full expressivity of genes because of environmental and/or physiological influence.

Further experiments have to be done to test these hypothesis. Accessions from Afghanistan were mostly tan in color (Fig. 7). This indicated that there may have been local morphotypes in some countries, but more accessions have to be observed.

Accessions with two types of hypocotyl color. There were seven accessions with two types of hypocotyl color. The pairs were compared among themselves. V1185, V1318, and V2548 were not compared because of missing data. V1992 and V1992-A had different calyx and corolla color. V2635 and V2635-A had different seed color and luster; and V2640 and V2640-A had different flowering dates. However, there was no definite differences between V2489 and V2489-A. Further study has to be done to find the importance of using hypocotyl color to split an accession into two.

Discussion. Stable qualitative characters are better than quantitative ones in identifying mungbean. The more useful qualitative characters are hypocotyl color, seed color, seed luster, pod color, etc. However, the genetics of these characters has to be understood first because it was observed that seven accessions had more than one seed color; and two accessions had

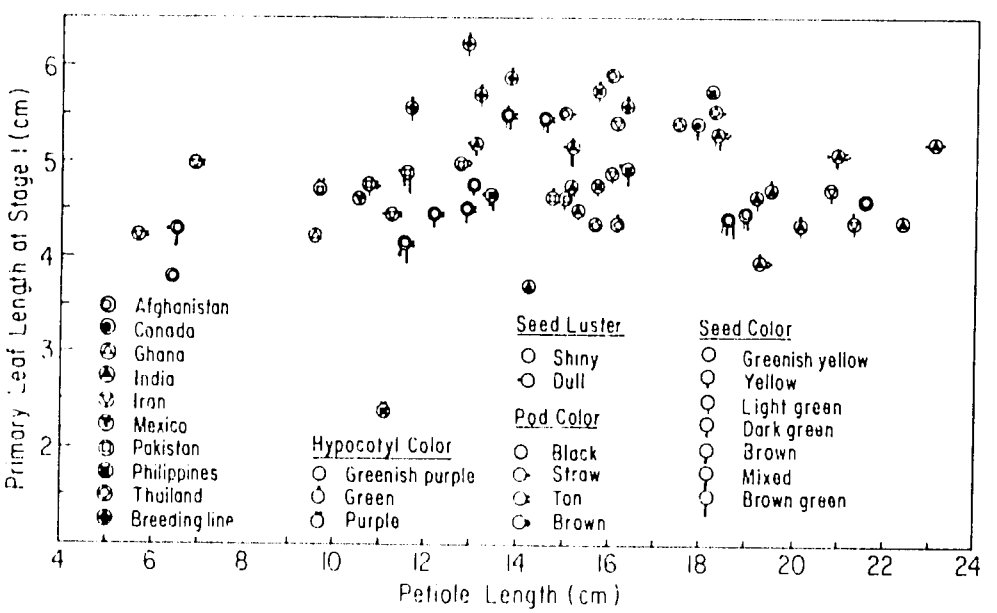


Fig. 7. Pictorialized scatter diagram for geographical distribution and for morphological characters.

more than one type of seed luster; but the original seeds had only one type (the original seeds might probably have more than one type already).

The geographical distribution of the morphotypes was not clear in this experiment. This may be due to the fact that only few accessions from each country were used in the study.

Though the leaf characters (except for the primary leaf length at stage 1) were less useful for classifying mungbean, they gave us some information about their correlation.

Accession V1160

V1160 is classified in our collection as mungbean. Our passport information shows that it is PI207655 or MO221, and that it originated from the Philippines. More detailed information is being requested from USDA.

Field observations in 1983 and 1984 showed that it had characters from both mungbean (*Vigna radiata*) and black gram (*V. mungo*). Its plant and flower characters were closer to that of black gram and the pod characters, to that of mungbean. However, the more important characteristic of V1160 is its "immunity" to diseases and pests in the field. It also competes well with weeds. It has a relatively slow initial growth, but a very vigorous later growth.

A full description of V1160 is given in Table 25. It has two unique characters which are not observed in both mungbean and black gram. These characters are as follows:

1. Deltoid primary leaf shape as compared to the normal acute type.
2. Petiolated primary leaf as compared to the normal almost sessile type.

V1160 has no glutamyl-methionine (16-17 min) peak according to the HPLC analysis which makes it difference from black gram (Fig. 8). In addition, the peak at 14 to 14.4 cm is not usually found in mungbean chromatograms. It may be of hybrid origin with characters from different genomes, probably mostly from mungbean and black gram. It could also be a new taxon. The glabrous nature of V1160 may relate it to *Vigna glabrescens*.

The botanical description and samples of seeds are now under preparation to be sent to Kew Garden, United Kingdom, and to Professor R. J. Marechal, Faculte des Sciences Agronomiques de l'Etat, Belgium for taxonomic identification.

Because of its "immunity" to diseases and pests in the field and its probable hybrid origin, it is a good potential of resistant genes and as a "bridging" taxon to allow difficult interspecific crosses to be done. However, it is very photoperiod-sensitive, responding favorably only to short days. Past experience showed that it will not flower in spring, and the number of days to flowering in autumn depends on the date of sowing (Table 26).

An experiment on flower induction by short-day treatments was carried out in autumn 1984 to provide information on flowering in V1160. This is necessary in the synchronization of flowering between V1160 and other parents for pollination. The experiment was planted on September 17, 1984 in four pots with three plants each per treatment. The treatments are the control and days shorter by 30, 60, 90, 120, 150 min. These regimes were imposed on October 21, 1984 until November 30, 1984

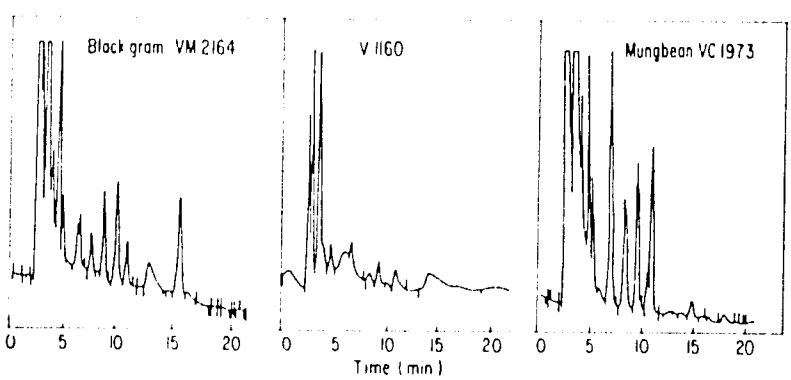


Fig. 8. HPLC chromatograms of V1160, black gram, and mungbean.

The results are summarized in Figs. 9 to 10 with the use of the cubic curve fitting. It can be seen that the treatments did hasten flowering and concentration of flowering, even if the day was shorter only by 30 min. The analysis showed that the cubic curve fitting was more suitable for this type of data. This was reflected in the reduction of residual sum of squares from quadratic to cubic term (Table 27).

The same experiment will be repeated in the coming spring season.

Table 25. Full description of V1160.

Descriptor	V1160
1. Growth habit	Erect
2. Stem color below primary leaf at seedling stage	All purple
3. Primary leaf shape[z]	Deltoid
4. Primary leaf length	2.71 ± 0.23 cm (2.3-3.2 cm) n = 20
5. Primary leaf width	2.00 ± 0.19 cm (1.6-2.3 cm) n = 20
6. Attachment of primary leaf[z]	Petiolated 1.79 ± 0.33 cm (1.1-2.3 cm) n = 20
7. Stem color	Purple
8. Stem pubescence[z]	Glabrous
9. Petiole length	12.05 ± 1.77 cm (9.2-14.7 cm) n = 20
10. Petiole color	Greenish purple
11. Color of petiole/leaf blade joint	Green
12. Petiolule length of terminal leaflet	1.57 ± 0.23 cm (1.0-2.0 cm) n = 20
13. Terminal leaflet shape	Deltoid
14. Terminal leaflet length	6.89 ± 0.78 cm (5.3-8.2 cm) n = 20
15. Terminal leaflet width	5.29 ± 0.68 cm (3.7-6.4 cm) n = 20
16. Distance from terminal leaflet base to its widest part	2.06 ± 0.29 cm (1.5-2.5 cm) n = 20
17. Leaf pubescence[z]	Glabrous
18. Leaf color	Green
19. Leaf venetion pigmentation	Pigmented
20. Calyx color	Purple
21. Corolla color	Greenish yellow
22. Raceme position	Intermediate
23. Pod color	Brown
24. Pod pubescence[z]	Glabrous
25. Pod length	7.74 cm (7.2-8.0 cm)
26. Seeds per pod	10.6 (9-13)
27. Number of clusters per plant	9 (5-20)
28. Pods per plant	33
29. Seed color	Black
30. Seed surface luster	Shiny
31. 1000-seed weight	33.7 g
32. Lodging	None
33. Days to flowering	84 (Fall, 1984)
34. Plant height at flowering	45 cm
35. Days to maturity	115 (Fall, 1984)
36. Plant height at maturity	52.8 cm (40-60 cm)

[z]Important characters.

Table 26. Number of days to flowering of V1160.

Year	Season	(Sowing Date)	Days to Flowering
1978	spring	(March 1)	Not flowering
1980	spring	(March 3)	Not flowering (June 18)
1982	spring	(March 10)	Not flowering
1983	autumn	(July 27)	124 (November 28)
1984	spring	(March 7)	Not flowering
1984	autumn	(August 28)	83 (November 19)

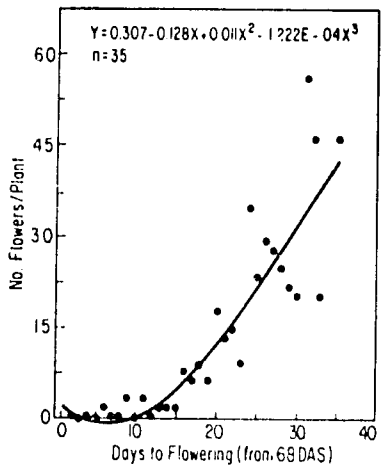
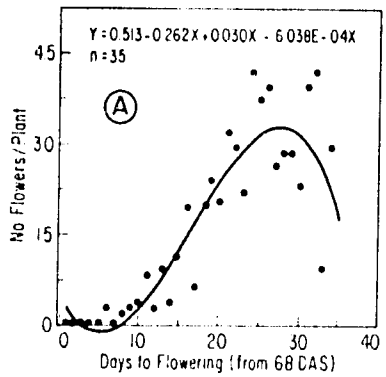
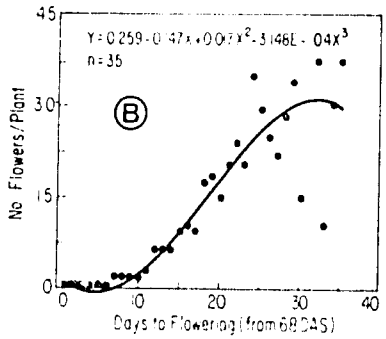
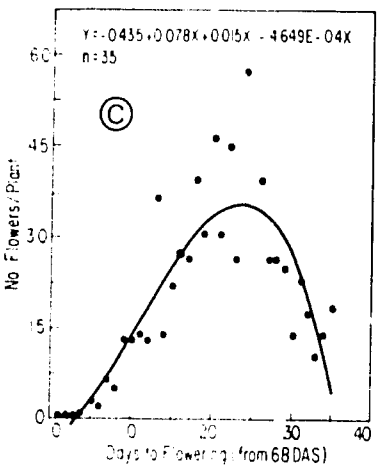
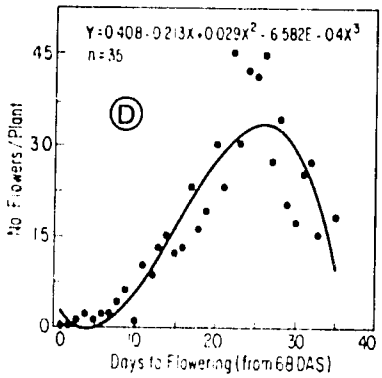


Fig. 9.
Days to flowering of the check plants.









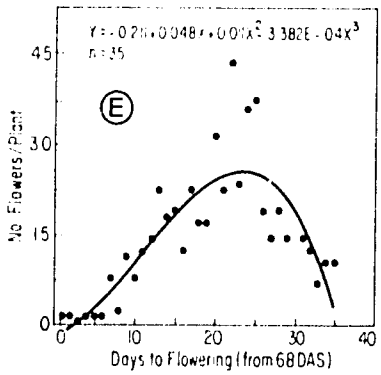


Fig. 10.
Days to flowering of V1160 on the –
A. 30-min treatment.
B. 60-min treatment.
C. 90-min treatment.
D. 120-min treatment.
E. 150-min treatment.

Table 27. Comparison of the quadratic and cubic curve fitting on flowering data.

Treatment	Total No. of Flowers/Plant	Quadratic Fitting		Cubic Fitting	
		residue square	S.D.	residue square	S.D.
Check	47.7	15.9211	0.70536	15.5821	0.70898
30-min	56.7	21.2518	0.81493	12.9686	0.64679
60-min	51.4	17.4520	0.73850	15.2019	0.70028
90-min	69.9	23 4514	0.85607	18.5425	0.77340
120-min	60.3	20.9726	0.80956	11.2821	0.60327
150-min	50 5	13.5907	0.65170	11.5481	0.61034

-45'-

Office of Information Services

Publications

Major publications. 1) AVRDC Organization and Plans (external review source document), 406 pp,; 2) AVRDC 1982 Progress Report, 337 pp.; 3) AVRDC Progress Report Summaries 1983, 82 pp.: 4) Report of the Third External Review, 176 pp.; 5) Response of the Board of Directors to the External Review, 37 pp.; 6) Vegetable Consumption and Production in Ilocos Norte, Philippines, 24 pp.; 7) Guidelines for Diagnostic Work in Plant Virology, 39 pp.; 8) Vegetables and the Quality of Life in the Year 2000, 7 pp.; 9) Centerpoint, August 1984, 6 pp.; 10) Agromyzid Flies in Java, 90 pp..

Miscellaneous publications. 1) 1984-85 Publication Catalog; 2) 1982 Highlights Sheet; 3) 1983 Highlights Sheet; 4) AVRDC Fact Sheet (three up-dated versions); 5) Vegetables in the Tropics (position paper for the external review); 6) Vegetable Production Training Course Flyer; 7) AVRDC 1984 Telephone Directory.

Reprints. 1) Taiwan's Specialized Vegetable Production Areas: An Integrated Approach (TB 1); 2) Farm Management Research on Cropping Systems (TB 2); 3) Four Approaches to Risk and Uncertainty for Use in Farm Management Extension (TB 3); 4) Summer Tomato Production in Taiwan (TB 6); 5) Why Farmers Plant What They Do (TB 8); 6) Improving the Marketability of Perishable Commodities (TB 9); 7) Proceedings of the Workshop on Pre-and Post-Harvest Vegetable Technology; 8) Procedures for Tomato Evaluation Trials; 9) AVRDC Crop Environment; 10) Suggested Cultural Practices for Mungbean; 11) Procedures for Chinese Cabbage Evaluation Trials; 12) Suggested Cultural Practices for Tomato; 13) Cultural Practices for Chinese Cabbage at AVRDC; 14) Evaluating AVRDC Soybeans; 15) Procedures for Sweet Potato Evaluation Trials.

Projects currently underway (and status). 1) 1983 Progress Report (advanced); 2) Proceedings of the workshop on Soybean in Tropical and Subtropical Cropping Systems (intermediate); 3) AVRDC: 10 Years of Progress (intermediate); 4) Centerpoint, December 1984 (advanced).

Public Relations

Publications with news or mention of AVRDC in 1984. 1) IBPGR SE Asia Newsletter (2 occasions); 2) Agricultural Science Digest; 3) Farmer Magazine; 4) Xerophthalmia Club Newsletter; 5) Horizons (USAID); 6) Hsing Nung Farm Magazine; 7) Harvest Magazine; 8) San-kin News (Japan); 9) North Thailand; 10) CGIAR Newsletter; 11) Chronic Horticulturae; 12) China Post; 13) China Times (2 occasions); 14) China Daily News; 15) HortScience; 16) USDA Experiment Station Newsletter; 17) IBM Newsletter; 18) Tainan Weekly News; 19) Agri-Week Magazine; 20) Searca Diary; 21) INTSOY Newsletter; 22) Information and Computer; 23) United Daily News (2 occasions) 24) Vita Newsletter; 25) Asahi Daily News (Japan); 26) USAID International Exchange News; 27) Benchmark Site News; 28) Vent-Rock Echoes; and 29) PIP Newsletter; 30) Time Magazine.

Radio reports about AVRDC. 1) Station DYVR, Radio Mindanao; 2) British Broadcasting Corporation (six occasions); 3) Australian Broadcasting Corporation.

Editing Services

Twenty-nine journal papers, conference papers, or general reports were edited by OIS in 1984 (not including papers edited for the soybean symposium and the 1983 Progress Report). The following is a breakdown by department: Chemistry-2, Entomology-7, ODA-3, B&M-1, Soybean Breeding-2, Virology-3, Outreach Programs-3, Seed Laboratory-2, Plant Pathology-2, Crop Management-1, Physiology-2, Training-1.

Printing and Art Services

The printshop processed 427 requests in 1984, representing a total of 1,300,000 printed pages (not including the last two weeks in December). This compares with 363 requests in 1983, representing slightly more than 1,000,000 pages.

The art services section processed 135 orders for figures, labels, etc. This number does not include jobs requested by OIS.

Photo Services

A total of 15,420 photographs were processed by OIS during the year. This includes 8,301 color slides; 2,084 blue slides, and 5,035 black and white prints. Approximately 20,000 photographs were processed in 1983 (exact figures are not available).

Major improvements were made this year in the quality of OIS photographs through the development and/or adaptation of studio techniques and technical processes. In addition, substantial savings were achieved in the overall operation of the OIS photographic section (Table 1).

Distribution

Requests. A total of 1,150 requests for publications were received in 1984 (not including requests for progress report reprints). This compares with 1,730 requests in 1983. The reduction in 1984 is attributable to a reduction in the number of Centerpoints issued during the year.

Readership. The OIS mailing list had 5,999 listings as of December 1984, including 538 libraries, as compared with 4,785 listings (404 libraries) in April 1983.

Book sales. A new publication pricing policy was established in 1984. As of June all readers were asked to pay for the Center's symposium proceedings, progress reports (after 1981), and other heavy publications. Our previous policy charged only residents in developed countries. As in the past, library copies continue to be free. Book sales in 1984 totaled US $2,515.70 compared with US $788.30 in 1983.

Postage. Postage costs in 1984 totaled NT$405,813 compared with NT$365,023 in 1983. This was primarily due to an increase in overall publication production and larger mailings to libraries and VIPs.

Time and delivery study. A time and delivery study was conducted in 1983-84 to determine the number of days required to ship AVRDC publications (by surface mail) to specific countries and to determine their condition upon arrival. All publications shipped during the study period contained a card that asked the recipient to note the date that the publications arrived and their condition. Two hundred and ninety-six cards (70%) of the 394 cards issued were returned. The longest delivery dates recorded are as follows: Chile (135 days), Colombia (154 days), Guyana (134 days), Ivory Coast (158 days), Nigeria (231 days), Guam (134 days), Indonesia (114 days), PNG (120 days), Sri Lanka (247 days), Vietnam (159 days). In the future, this information can be used to make decisions about mailing free publications to key cooperators and donors.

A total of 296 recipients reported that the publications arrived in excellent or satisfactory condition; no "unsatisfactory" reports were received.

Requests for progress report reprints. To identify the areas of greatest interest to our readership, and thereby help to plot future publication strategies, an effort was made to keep track of all reprint request cards (for 1982 Progress Report reprints) returned by readers of the Progress Report Summaries. A total of 160 readers (7.5%) returned the cards. A breakdown of the reprint requests according to crop and discipline is presented in Table 2.

This information provides a base line from which we can chart future publication strategies and the effectiveness, or lack of effectiveness, of the reporting strategy of the progress reports and the summaries. A similar project is being conducted with 1983 reports for purposes of comparison.

Table 1. Photographic expenses and sales, 1981-84 (NT$).

	1981	1982	1983	1984
Processing	161,930	140,500	128,660	90,927
Supplies	185,720	153,760	140,886	127,247
Total	347,650	294,360	269,546	218,174
Sales	8,590	17,727	51,312	37,516
Balance	339,060	276,533	218,234	180,658

Table 2. Breakdown of requests for 1982 Progress Report reprints.[z]

Discipline	Tomato	Chinese Cabbage	Sweet Potato	Mungbean	Soybean	Total
Breeding	61	42	42	46	50	241
Pathology	50	34	–	39	45	168
Entomology	50	42	44	37	43	216
Physiology	55	37	–	40	43	175
Chemistry	–	–	–	–	–	33
Gardens	–	–	–	–	–	39
Soils	–	–	–	–	–	47
Management	–	–	–	–	–	72
Economics	–	–	–	–	–	36
Anthropology	–	–	–	–	–	18
Total	216	155	86	162	181	1,045

[z]Total requests = 1,045.

Appendix

463

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Ministry of Agriculture, Philippines
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Mr. Takasuke Yamaguchi
Interchange Association
Japan

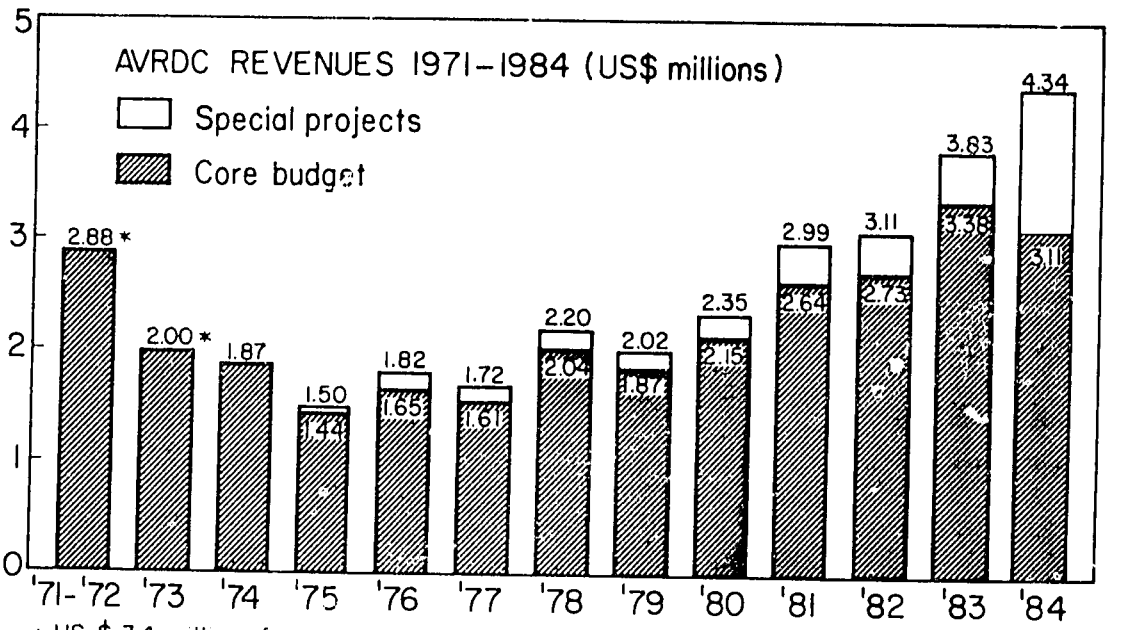
Dr. Prasan Yingchol
Kasetsart University
Thailand

Finances

AVRDC's projected budget for 1984 was US$ 4,750,000, compared with an actual income of US$ 4,336,727 and expenditures of US$ 4,518,249. Core funding was provided by the governments of Taiwan, the United States, the Philippines, the Republic of Korea, Japan, Thailand, and the Federal Republic of Germany.

Grants and other forms of assistance were also received from:

The Asian Development Bank
The International Development Research Centre (Canada)
The International Board for Plant Genetic Resources
Taiwan Council for Agriculture
Taiwan National Science Council
International Soybean Program (INTSOY)
American Cyanamid Company
Duphar BV
Merck & Co. Inc.
Land O'Lakes, Inc.
Taiwan Kagome Co.
Teh Hua Chemical & Pharmaceutical Co.,



* US $ 3.4 million for capital expenditure, 1971-73

Germplasm Recipients 1984

Anguilla, British
Corito Trading Company, Ltd.

Antigua
Caribbean Agricultural Research & Development Institute

Argentina
Facultad de Ciencias Agrarias de Rosario

Australia
Commonwealth Scientific and Industrial Research Organization
Department of Agriculture
Department of Primary Production
Redlands Horticultural Research Station
Seed Testing Station

Bahamas
Department of Agriculture

Bangladesh
Bangladesh Agricultural Research Institute
Institute of Nuclear Agriculture
International Agricultural Development Service

Barbados
Hi-GRO Gardens, Ltd.

Belgium
University of Ghent

Belize
Carribean Agricultural Research and Development Institute

Bolivia
Comite Central Menonita
Est Experimental "Green Chaco"
Moxos Experimental Station

Brazil
Centro de Pesquisa Agropecuaria Tropico Umido
Centro Nacional de Recursos Geneticos
CEPLAC
Programa De Pesquisa, TOCEPAR

Brunei
Pusat Latihan Pertanian Sinaut
Sinaut Agricultural Training Center

Burkina Faso
Institut de recherche pour les huiles et oleagineux
Centre d'experimentation du riz et des cultures irriguees

Burma
IRRI

Cameroon
IRA Nkolbisson Center

Canada
Agriculture Canada
King Grain, Ltd.
Ridgetown College of Agricultural Technology
Smithfield Experimental Farm
Stocks Seed, Ltd.
University of Guelph

Caroline Islands
Agriculture Division, Truk
OISCA I.D.M.

Colombia
Centro Internacional de Agricultura Tropical
Coordinator Nal. Leguminosas de Grano y Oleaginosas Anuales
Federacion Nacional de Cafeteros de Colombia
Institute Colombiano Agropecuario
Instituto Linguistico de Verano

Comoros
CEFADER

Congo
Universite Marien Ngouabi

Cook Islands
Ministry of Agriculture and Fisheries
Tokoitoku Research Station

Costa Rica
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Ministerio De Agricultura y Ganaderia
Palm Research Program
Proyecto Agroforestal
Taiwan Technical Mission
Universidad de Costa Rica

Cyprus
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Denmark
J. E. Ohlsens Enke A/S

Dominican Republic
Centro de Desarrollo Agropecuario
Taiwan Technical Mission

Egypt
Agricultural Research Center
Ministry of Agriculture

El Salvador
Centro Nacional de Tecnologia Agricola

Ethiopia
International Livestock Centre for Africa
Ministry of Agriculture (Add)
Nazareth Agricultural Research Station
UNDP/FAO

Fiji
Legalega Research Station
Sigatoka Research Station

France
Union des cooperatives agricoles Armagnac-Bigorre

Gambia
St. Augustines High School

Ghana
Crops Research Institute
Dodowa Cooperative Multi-Purpose Society, Ltd.

Guatemala
Instituto de Cinecia y Tecnologia Agricolas
Personero del Jefe de Estado
Taiwan Technical Mission

Guadeloupe (France)
Institut national de la recherche agronomique

Guam (USA)
University of Guam

Guinea
United Nations Development Program

Haiti
A Christian Outreach of the Baptist Haiti Mission
Catholic Relief Services Haiti Program
Instituto Interamericano de Cooperacion para la Agricultura
Taiwan Technical Mission

Kampuchea
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India
Andhra Pradesh Agricultural University
Ankur Agricultural Research Laboratory
Bhabha Atomic Research Center
Central Agricultural Research Institute
College of Agriculture & Technology
CYB Institute
FIPPAT
G. B. Pant University of Agriculture and Technology
Haryana Agricultural University
ICAR Research Complex for N.E.H. Region
IFFCO
India Institute of Horticultural Research
Indian Agricultural Research Institute
J. N. Agricultural University
Kerala Agricultural University
Khedut Samakari Jin, Ltd.
Merryweather Food Products, Ltd.
National Bureau of Plant Genetic Resources
National Pulse Research Station
Nimbkar Agricultural Research Institute
Orissa University of Agriculture & Technology
Punjab Agricultural University
Soya Production and Research Association
Tamil Nadu Agricultural University
The Atul Products, Ltd.
The Cochin Malabar Estates and Industries, Ltd.
University of Agricultural Science & Technology
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Indonesia
Agricultural Training Center
Akademi Farming Semarang
Bali Ganti Sena Foundation
Bogor Agricultural University
Bogor Central Research Institute for Food Crops
Central Research Institute for Food Crops
Central Research Institute for Horticulture
Dinas Pertanian Tanaman Pangan
Lembang Research Institute
M. A. C. S. Research Institute
MARIF
Maros Research Institute for Food Crops
NAEA, Pasar Jumat Research Centre
NTT Livestock Development Project
Pilot Project on Integrated Soya and Food Crop Production
P. T. Melati Gambir Mas
P. T. Uniroyal Sumatra Plantations
Taiwan Technical Mission
Subbalai Penelitian Tanaman Pangan Sumani
Sukamandi Research Institute for Food Crops
Sukarami Research Institute for Food Crops
SURIF
TAD Seed Improvement
Transmigration Area Development Project
Universitas Jambi
Universitas Sriwijaya

Iran
Seed & Plant Improvement Institute
University of Isfahan
University of Tabriz

Italy
Consiglio Nazionele delle Ricerche
UN Food and Agricultural Organization

Jamaica
Ministry of Agriculture

Japan
Association for International Cooperation of Agriculture & Forestry
Chiba University
Kikko Foods Corporation
Kirin Brewery Co., Ltd.
Kyushu University
Nagasaki Agricultural & Forest Experiment Station
Nagoya University
Okinawa Tropical Agriculture Research Center
Okinawa Federation of Agricultural Crops
Shizuoka Agricultural Experimental Station
Takii and Company, Ltd.
T. Sakata & Company
Tsukuba International Agricultural Training Center

Jordan
Jordan Valley Agricultural Project

Kenya
Agricultural Office Dept.
Bombolulu Coast Workshop for the Handicapped
Dryland Farming Research and Development Project
Institute for Rural Development
International Centre for Insect Physiology and Ecology
Karamoja Development Programme, Moroto Headquarters
Ministry of Agriculture and Livestock
National Horticultural Research Station

Kiribati
Kiribati Field Office

Korea, Republic of
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February 9 - Breeding Goals for Sweet Potato in Asia and the Pacific, Steve Lin, Sweet Potato Breeder, AVRDC.

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March 15 - INTSOY Microbiology: The Past, Present, and Future, Chris Stearn, AVRDC Soil Microbiologist, AVRDC.

March 22 - Plant-Plant Interaction in Taiwan Agro-ecosystems, C. H. Chou, Institute of Botany, Academica Sinica.

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April 19 - Plant Tissue Applications in Agriculture, Huang Li-chun, Academia Sinica.

May 3 - Farming System Research, Linnea Karlsson, AVRDC.

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July 2 - Vegetable Production and Management in Western Australia, Terry Hill.

August 16 - Chemical & Nutritionai/Agricultural Studies of Sweet Potato and Other Root Crops in the South Pacific, J. Howard Bradbury.

September 4 - Theoretical Research and Applied Research - A Review of My Research Method, Chang-chi Chu.

October 18 - Nematodes Predispose Plants to Bacteria, Niramit Pratoomrat.

November 1 - Vegetable Research and Production in West Malaysia, Chang-chi Chu.

November 6 - Incorporation of Multiple Disease Resistance in Mungbean through Interspecific Hybridization, B. A. Satyan.

November 8 - Hormonal Studies on the Bud Dormancy Problems in Subtropical Viticulture, Cheng-yung Cheng, National Taiwan University.

November 22 - Down on the farm. A Documentary on Farming Practices in the US, Chris Stearn, AVRDC.

December 13 Sexual Barrier of Crops in Post-Pollination, Chou-tou Shii, Associate Professor, National Taiwan University.

December 17 - Physico-Chemical Properties of Volcanic Ash Soils in Japan, Shingo Iwata.

Senior Personnel

Administration

G. W. Selleck, Ph.D., Director General
Paul M. H. Sun, Ph.D., Deputy Director General
Michael Chin, B.S., Director of Administration
David I. K. Chi, G.A., C.P.A., Comptroller
Paul Yang, B.S., Superintendent, Buildings and Maintenance*
Ann Hwa, Manager, Food and Dormitory Services

Chinese Cabbage and Tomato Breeding

Romeo T. Opena, Ph.D., Program Leader (Horticulture) and Plant Breeder (tomato)
Lien-chung Chang, B.S., Assistant Specialist
Jen-tzu Chen, Assistant Specialist

Mungbean Breeding

Chang-Soon Ahn, Ph.D., Associate Plant Breeder (mungbean)*
Jin-hu Chen, B.S., Research Assistant*
Ren-cheih Jin, B.S., Research Assistant
Miao-miao Hsu, M.S., Principal Research Assistant**

Soybean Breeding

S. Shanmugasundaram, Ph.D., Program Leader (legumes) and Plant Breeder (soybean)
Kun-te Lee, Senior Research Assistant
Li-fen Chen, M.S., Principal Research Assistant

Sweet Potato Breeding

Steve S. M. Lin, Ph.D., Associate Plant Breeder (sweet potato and processing tomato breeder)
Ching-hsiung Hung, M.S., Principal Research Assistant
Chei-shan Cheng, B.S., Senior Research Assistant

Plant Pathology

Arnold T. Tschanz, Ph.D., Associate Plant Pathologist (Legumes), Head Plant Pathology
Tien-cheng Wang, B.S., Associate Plant Pathologist
Jiahn-yao Weng, M.S., Principal Research Assistant*
Min-chu Tsai, M.S., Principal Research Assistant**
Yao-hua Cheng, B.S., Research Assistant
Ming-ming Chao, M.S., Principal Research**
Sylvia K. Green, Ph.D., Associate Plant Pathologist (virology)
Ting-chin Deng, M.S., Principal Research Assistant*
Dar-ren Lee, M.S., Principal Research Assistant
Yen-jen Kuo, M.S., Principal Research Assistant**
Jonathan E. Yuen, Ph.D., Associate Plant Pathologist (horticulture)/computer specialist
Hsiou-chen Huang, M.S., Principal Research Assistant
Hao-jan Lin, B.S., Research Assistant

Entomology

N. S. Talekar, Ph.D., Entomologist
Bor-shyan Chen, B.S., Principal Research Assistant*
Li-yu Sun, B.S., Research Assistant*
Hui-chin Yang, B.S., Research Assistant
Song-tay Lee, B.S., Research Assistant
Ying-ehr Hong, B.S., Research Assistant*
Chih-pin Lin, B.S., Research Assistant
Su-chong Kuo, B.S., Research Assistant
Shang-wen Hwang, B.S., Research Assistant**

Plant Physiology

George C. Kuo, Ph.D., Plant Physiologist
Mei-chen Shen, M.S., Principal Research Assistant*
Bih-jien Shen, M.S., Principal Research Assistant*
Huei-mei Chen, M.S., Principal Research Assistant
Hsiu-chu Chen, M.S., Principal Research Assistant

Chemistry

Samson C. S. Tsou, Ph.D., Program Leader (Nutrition, Environment and Management) and Biochemist.
Meng-huey Yang, M.S., Principal Research Assistant*
Kuang-kung Kan, M.S., Principal Research Assistant
Anna Linnea Karlsson, M.S., Project Employee*
Shyun-shyun Lee, M.S., Principal Research Assistant**
Shu-jen Wang, M.S., Principal Research Assistant**

Garden Programs

Jack Gershon, Ph.D., Nutritionist
Yen-chin Chen, M.S., Principal Research Assistant
Anna Linnea Karlsson, M.S., Project Employee**

Soil Science

Hideo Imai, Ph.D., Soil Scientist
Chin-hua Ma, B.S., Principal Research Assistant
Jiunn-yann Lin, M.S., Principal Research Assistant*
Chi-hsin Lu, M.S., Principal Research Assistant**

Crop Management

Adisak Sajjapongse, Ph.D., Associate Crop Management Specialist+
Yu-chi Roan, B.S., Assistant Specialist
Mei-huey Wu, B.S., Senior Research Assistant

Agricultural Economics

Hsu-yu Huang, M.S., Principal Research Assistant

Soil Microbiology

William C. Stearn, Soil Microbiologist
Lee-ju Chen, M.S., Principal Research Assistant

Training and Development

Diosdado V. Castro, M.S., Training Specialist
Sen-hsiung Lai, B.S., Assistant Development Officer+
Yuan Yung, B.S., Senior Training Assistant*
Yuan-chin Yang, B.S., Training Assistant
Jia-chi Cheng, B.S., Training Assistant**

Information Services

E. W. Sulzberger, M.A., Information Specialist (Head, Office of Information Services)
Allen Cambronne, B.A., Information Assistant*

Library

Teng-hui Hwang, B.A., Senior Librarian

Experimental Farm

Teng-sheng Tu, B.S., Farm Superintendent

Seed Laboratory

Chong Seng Tay, Ph.D., Research Associate
Anne M. Dourado, Ph.D., Post Doctorate Fellow (IBPGR)*
Yung-kuang Huang, B.S., Research Assistant
Wen-hsiu Kuo, B.S., Research Assistant**

Statistical Services

Keiji Kamiyama, B.S., Associate Scientist in Statistics and Computers*
Makoto Nagai, B.S., Scientist in Biometry and Head of Statistical Services**
Hsien-yang Tien, B.S., Senior Computer Assistant+
Ming-zen Chang, B.S., Statistical Assistant

Computer Services

Jonathan E. Yuen, Ph.D., Associate Plant Pathologist (horticulture)/computer specialist
Hsien-yang Tien, B.S., Computer Assistant+

Bilateral Programs

Benjamin P. Legaspi, Affiliate Horticulturist, Philippine Outreach Program
Jung Ho Kim, Ph.D., Affiliate Horticulturist, Korean Outreach Program
Charles Y. Yang, Ph.D., Director and Resident Scientist, Thailand Outreach Program
El Mostafa Saadaoui, Ph.D., Resident Scientist, Malaysia Outreach Program

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* Left during the year.
** Arrived during the year.
+ Transferred.