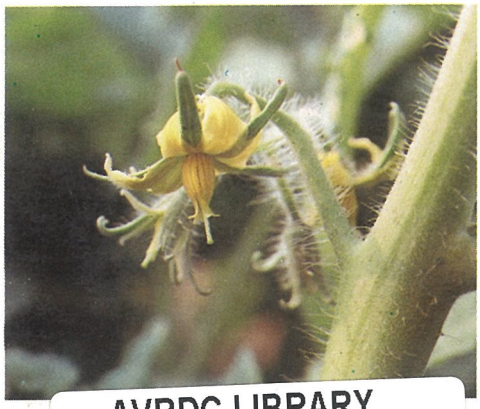
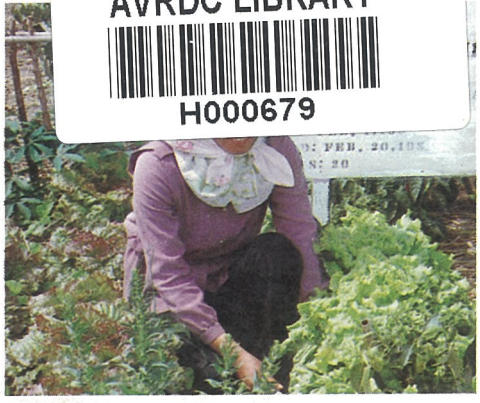
AVRDC

1981 Progress Report



1981 Progress Report

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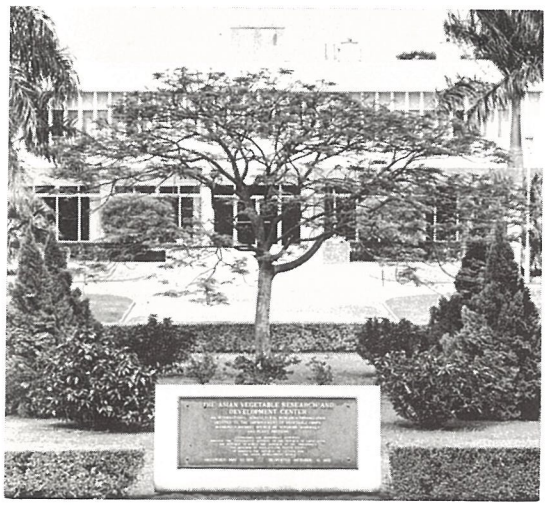
About AVRDC



AVRDC is the international research and training center charged with the responsibility of improving vegetable crop production in the tropics. Its scientific staff, representing ten countries, conducts research aimed at increasing the production potential of tomato, Chinese cabbage, sweet potato as well as soybean and mungbean. The Center's research agenda also includes the study of the nutritional, environmental and management factors that influence vegetable production in the tropics. Emphasis is similarly directed to scientific and training programs conducted in collaboration with national and international research organizations, agricultural development agencies and institutions of higher education.

About This Report

Readers who are familiar with AVRDC's *Progress Reports* will find this year's edition to be somewhat different than those of the past. The essential change is that the 1981 report utilizes abstracts to document the Center's research activities. As a consequence of this new format, the report does not provide extensive reference to the methods and materials used in various experiments or the bulk of data recorded. Readers who require this type of information are invited to write to AVRDC's Office of Information Service for more details. Comments about the new reporting format and suggestions for the future are also welcome.

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Director's Foreword

In last year's *Director's Foreword* I discussed the role that vegetables and legumes can play in meeting crop production and human nutrition requirements in the tropics. This year I would like to expand on that theme and discuss the steps that AVRDC has taken to meet those requirements.

Center scientists began their work in 1973 with the objective of increasing the production potential of tropical vegetables and legumes and, in turn, providing consumers with the vitamins, minerals and plant proteins that these crops can provide. As a result of their research, 33 improved lines have been released to farmers, while more than a score of AVRDC selections have been used by national research programs to develop locally adapted cultivars.

These materials, which essentially represent the first generation of AVRDC research, are now being superceded by a new series of selections that promise to increase production and nutrition potential even further. They include stable, high-yielding, seasonally-adapted soybeans; mungbeans with multiple disease and insect resistance; tomato and Chinese cabbage selections that are tolerant of heat and flooding; and sweet potatoes that can meet consumer and nutrition standards in a broad range of environments

The development of these materials is primarily due to a research program that encompasses a host of different scientific disciplines at the earliest stages of planning and development. AVRDC's chemists and nutritionists, for example, identify lines with high nutrient levels and subsequently assist breeders in incorporating these characteristics into promising breeding materials. Similarly, entomologists aid in the breeding of new selections by identifying insect resistant materials, while AVRDC pathologists work on the development of lines that can withstand the pressures of viral, fungal and bacterial diseases.

As new selections are developed, crop management specialists, soil scientists and economists then assess the new materials and characterize their performance in response to soil type, minimum and optimum fertilizer requirements, row spacing, drought tolerance and economic viability. Research is also conducted to determine the response of the new lines to different environmental parameters,

thereby indicating their adaptability to seasonal and ecological variations.

Ultimately, however, multi-location field testing is required to confirm the overall adaptability of a new selection. For this reason, the Center's bilateral and development programs in Korea, the Philippines and Taiwan routinely test experimental lines under a variety of different environments. In addition, our newly established bilateral project in Thailand will specifically address itself to the potential and adaptation of AVRDC crops grown under the conditions found on the Southeast Asian mainland.

Although each of these programs plays an important role in AVRDC's research efforts, they represent only one aspect of the Center's overall field testing program. At the present time, AVRDC cooperates with research programs in more than 75 countries around the world. These activities encompass the systematic distribution of improved germplasm, advanced multi-location testing and regular collaboration between scientists supported by events such as our 1981 International Sweet Potato Symposium.

In addition, AVRDC is now pursuing a garden research project to assist nutrition intervention programs at the national level in utilizing a wide range of vegetable and legume crops. Known as the Nutrition Garden Program, this project completed its first full year of operations in 1981 and successfully developed a number of gardening systems applicable to the cropping patterns of Asian farmers. Included are small-scale, low-input gardens that can be used to improve nutrition levels in the home or at school, as well as gardens specifically designed to address nutrition related diseases such as blindness caused by the lack of Vitamin A.

In the final analysis, however, the successful introduction of AVRDC technologies will depend on the capabilities of national research and extension programs to effectively adapt and extend research results. For this reason, the Center places a priority on the training of research and production scholars from national programs. Each year since 1974, AVRDC has provided training programs in such fields as plant breeding, pathology, entomology, physiology, nutrition and crop management. In addition, planning is now underway for the inauguration of a new training program in Thailand specifically designed for national research and production personnel working in Southeast Asia.

These efforts, when combined with our crop and nutrition research programs, form the basis of AVRDC's mandate for increased food production of higher quality and diversity. With continued perseverance they should lead to greater economic security, nutritionally balanced diets and a healthier, more productive life for the peoples of the tropics.

G. W. Selleck
Director

TOMATO

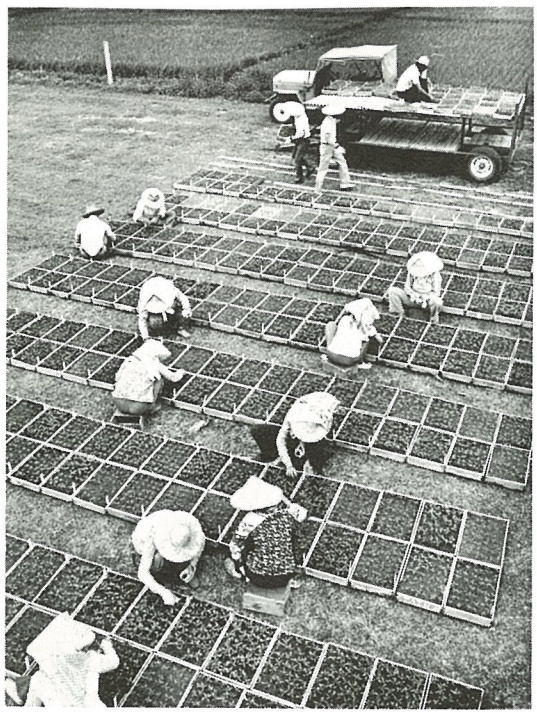
Introduction

Perhaps more than any other crop, tomato holds the promise of increasing farmer incomes and improving the diets of rural and urban populations. After eight years of research, AVRDC has successfully developed a series of high yielding, tropical tomatoes suitable either for processing purposes or fresh consumption. These lines, which have demonstrated superior performance across a wide range of environments, have now been released to farmers in Fiji, Guam, Indonesia, Malaysia, Panama, Papua New Guinea, Singapore, the Seychelles, Sri Lanka, Taiwan, Thailand and the U.S.A.

Each of these releases is essentially the end-product of a research program that concentrates on the breeding of tomato selections with high yield and Vitamin A content, resistance to insects and diseases as well as stable performance during the tropical summer. In 1981, for example, studies were conducted to evaluate a number of new breeding lines incorporating the best traits of AVRDC's older selections. Included were eight lines that outyielded the most commonly grown processing tomato in Taiwan and four heat tolerant lines that provided good yields in advanced summer trials.

While these results indicate a promising future for AVRDC tomatoes, the Center continues to give priority to studies that emphasize the development of selections with resistance to viral, fungal and bacterial diseases and insects such as the tomato fruitworm. A considerable invest-

ment is also being made to gain a better understanding of the tomato fruiting process and thereby pinpoint the factors that influence heat and flooding tolerance.



Preparing tomato seedlings for advanced yield trials.

Plant Breeding

Yield trials

In winter preliminary yield trials of AVRDC processing tomatoes, eight lines outyielded check TK 70, the most commonly grown processing tomato cultivar in Taiwan. Two lines, CL 1104-0-0-29-3 and CL 197-0-2-3-2-2 developed fruit sizes ranging from 37g to 58g, comparable to TK 70 which ranged in size from 48g to 87g. All eight lines will be entered in advanced yield trials in 1982 and evaluated against TK 70 for processing quality.

Four AVRDC tomato breeding lines produced average yields ranging from 14.3 t/ha to 18.2 t/ha over five planting dates in summer advanced yield trials. Check cultivar L 387 yielded an average of 3.6 t/ha by comparison. A combined analysis of variance showed insignificant variety (V) x time of planting (T) interaction for yield and fruit set, suggesting that these factors were not affected by planting date. However, there was significant V x T interaction for the number of days to flowering, maturity and most quality characteristics.

Pathology

Detection of tomato mosaic virus (TMV) strains

The major tomato production areas in Taiwan were surveyed for naturally occurring strains of tomato mosaic virus. A total of 158 samples, out of 345 tested, were found to contain TMV as indicated by local lesion formation on *Nicotiana sylvestris*. These

samples were further strain-typed by differential host reactions on *Lycopersicon esculentum* cv. GCR (+/+), Perou-2 (Tm2/Tm2), CSTMV-18 (Tm1/Tm1) and delissa ($Tm2^a/Tm2^a$). TMV strains 0 and 1 were identified, with strain 1 the most prevalent.

TMV and cucumber mosaic virus (CMV) inoculation methods for mass screening

Various inoculation techniques were assessed to determine the most efficient method for TMV and CMV mass screening work. For TMV, a 100% infection rate was consistently obtained when the tomato plants were inoculated at the first leaf stage with 0.5 ml of a 1:50 dilution of infected *Nicotiana tabacum* cv. Samsun tissue in a phosphate buffer (0.01 M, pH 7.0, with 2% Celite added).

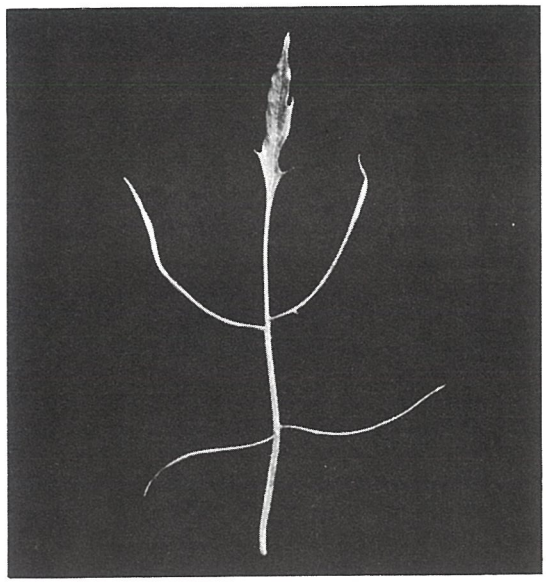
A 100% infection rate of CMV was consistently obtained when plants were inoculated at the first leaf stage with 0.5 ml of a 1:50 dilution of infected *N. tabacum* cv. Samsun tissue in 100 ml phosphate buffer (0.01 M, pH 7.0, containing 0.1% thioglycollic acid, with 2% Celite added). Inoculation by air pressure (3.5 kg/cm^2 at 10 cm distance) or by hand was equally effective.

The effect of seed treatments for TMV control on seed germination

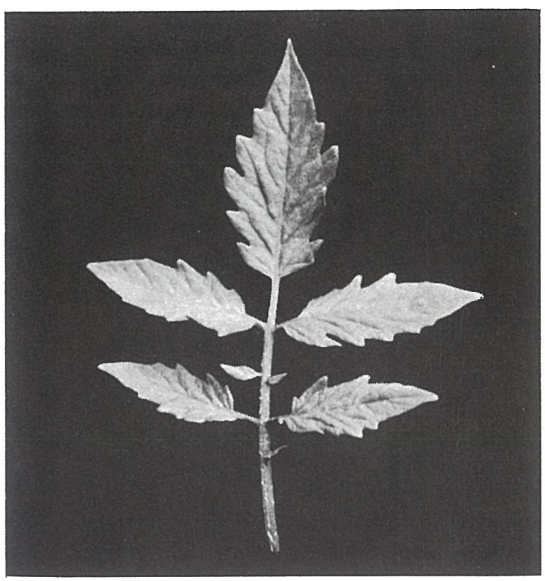
Several seed treatments are known to be effective in reducing seed-transmitted TMV. Four of these treatments (70°C for four days, 78°C for two days, 78°C for three days, 12.5% trisodium phosphate for 20 minutes) were used on 14 commercial tomato cultivars to determine their effect on seed germination. Except for one cultivar, seed treatment did not significantly reduce germination ($p=0.05$) compared with the untreated control.

Persistence of TMV in the soil

Soil samples were collected from 16 AVRDC fields having various histories of tomato



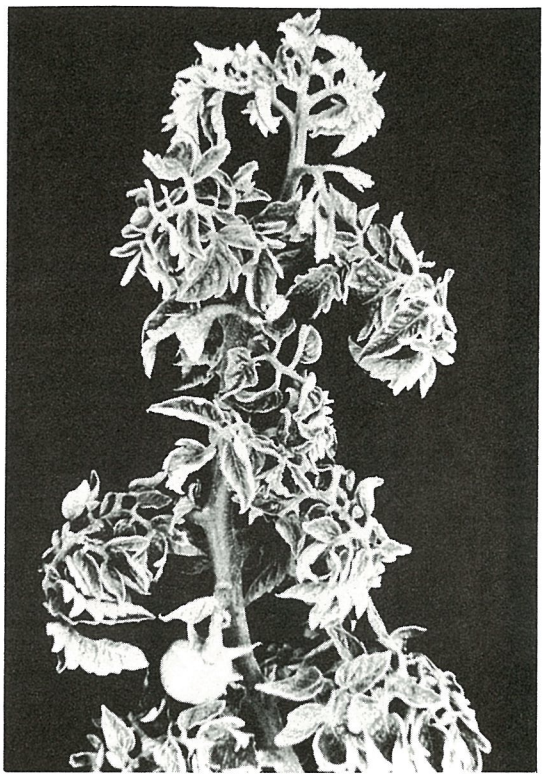
A cucumber mosaic virus infected tomato leaf with severe shoestring symptoms (above) compared with a healthy leaf (below).



cropping, and analyzed for the presence of TMV. TMV was detected in soils under tomato cultivation at the time of sampling, and soils from which tomatoes had been harvested three months earlier. TMV was not detected in the soil in fields where tomatoes had been harvested four to six months prior to sampling. It appears that a fallow of at least three months or a crop rotation with a resistant or immune species will reduce the TMV inoculum in the soil.

Possible presence of tobacco leaf curl virus (TLCV) in Taiwan

Studies conducted in 1981 indicate that a white fly-transmitted agent such as TLCV or tomato yellow leaf curl virus is likely present in Taiwan. In fall tomato plantings in 1980 and 1981, plants exhibited virus symptoms that could not be transmitted by sap inoculation. The symptoms included stunting at the branch tips, and yellowing and curling of the leaves. In white fly transmission tests, similar symptoms were produced on *Datura stramonium* and *Lycopersicon esculentum* cv. Moneymaker, Peron-2 and Delissa. In agar gel immunodiffusion tests using TLCV antiserum, both the original field samples and samples subjected to white fly transmission tests gave single precipitin lines. Several samples were also sent to the University of Osaka in Japan where researchers determined that the agent causing the leaf curl symptoms in Taiwan is serologically related to TLCV isolates collected in Japan.



Leaf curl symptoms induced by white fly transmission.

1981

Screening for resistance to bacterial wilt

A total of 1011 tomato breeding lines were screened for resistance to bacterial wilt (*Pseudomonas solanacearum*). All plants were inoculated at the three-leaf stage by clipping the lower leaves with scissors dipped in a 10^9 bacterial/ml water suspension of a highly virulent isolate, AVRDC No. 76. Plants were evaluated 15 days after inoculation and resistance ratings were based on disease in-

cidence. Four F_5 breeding lines rated resistant (8%–16% wilted plants), and 13 breeding lines rated moderately resistant (21%–40% wilted plants).

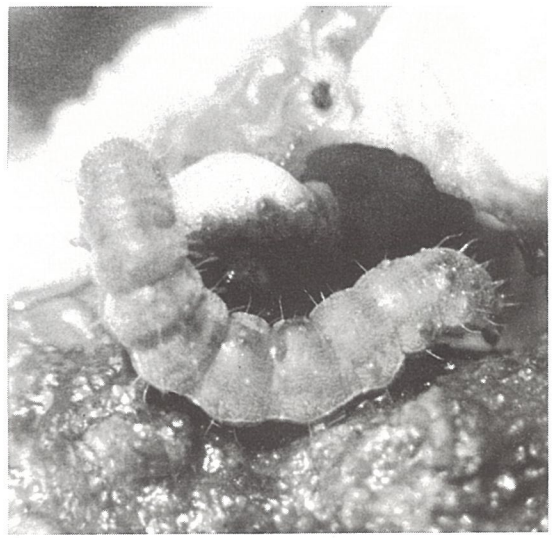
Entomology

Chemical control of the tomato fruitworm

Three synthetic pyrethroids (fenvalerate, permethrin and decamethrin) gave the most effective fruitworm (*Heliothis armigera*) control for tomato based on percent damaged fruits. Fruit damage and yields of the three treatments ranged from 0.15% to 0.27% and 33.4 t/ha to 37.8 t/ha respectively, compared to the control with 2.88% damage and a 26.9 t/ha yield.

Cultural control of the aphid and fruitworm

Nylon net covers provided the lowest aphid infestation, least fruitworm damage (4.45% damaged fruits) and greatest tomato yield (50.8 t/ha) in an experiment evaluating different cultural practices for aphid and fruitworm control. Aluminum foil, as well as clear and black plastic mulches, also gave satisfactory insect control and yields of 50.3 t/ha, 47.8 t/ha and 47.5 t/ha, respectively. The untreated check showed insect infestations of up to 100 insects/plant, 12.6% fruitworm damage and a yield of 38.6 t/ha. Intercropping (58 combinations) did not control aphids and resulted in reduced fruit yields.

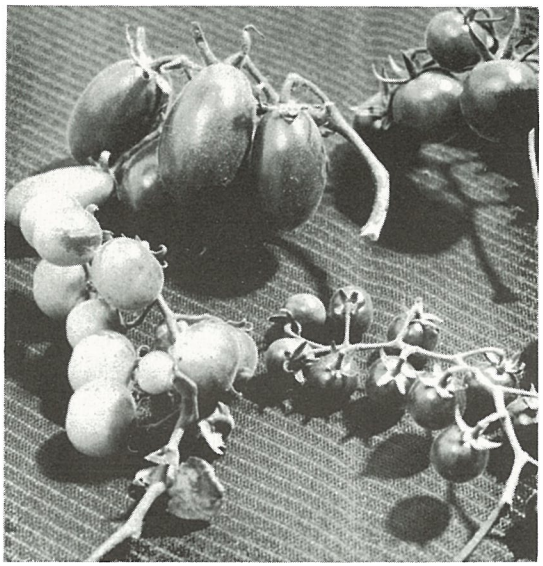


The tomato fruitworm - Heliothis armigera.

Physiology

Heat stress and fruit setting

A study of tomato fruit setting under heat stress demonstrated that high temperature had an overriding effect on pollen produc-



Wild tomato accessions with superior fruit setting ability (above) are now being used to develop heat tolerant lines capable of producing high, stable-yields during the tropical summer.

tion and viability, regardless of the tested cultivar's heat tolerance or sensitivity. Two heat tolerant and three heat sensitive tomato accessions were planted on six dates between April and August 1981 and evaluated for pollen production, pollen viability and fruiting ability. Pollen viability was less than 10% in all but one of the plantings. Although there were cultivar differences in pollen production, pollen viability and fruiting ability, the three factors were significantly negatively correlated with a heat degree-hour sum (AVRDC Progress Report 1980) above 21°C for all entries.

Evaluation of specific physiological characteristics involved in heat tolerance

Physiological studies were conducted to evaluate individual physiological and morphological aspects involved in the complex tomato fruiting process under high temperature stress. Fifty-four tomato accessions and breeding lines previously identified as heat tolerant were screened for fruiting ability and stigma exsertion under high temperatures. Forty of these entries were further screened for pollen production, pollen viability and anther cone splitting under high temperatures. In both screenings, pot-grown plants with two clusters were subjected to either high or normal temperatures (32-37/20-21°C or 26-30/18-21°C day/night).

All entries showed reduced pollen production, pollen viability and fruiting ability, as well as greater stigma exsertion and anther cone splitting under high temperatures. However, some of the entries showed only slight differences between high and normal temperature treatments. Under high temperatures, five entries showed high fruit setting ability, 11 showed low anther cone splitting, six showed low stigma exsertion, three had high pollen production and four showed high pollen viability. These genotypes are now being combined in the tomato improvement program for heat tolerance.

Flood tolerance studies

Six tomato accessions were rated flood tolerant on the basis of two screenings that involved oxygen restriction in the root system. The six accessions were selected from 25 that were grown in an aerated water culture with two mM dinitrophenol added to block oxidative phosphorylation in the root systems. Tolerance ratings were made on the basis of shoot growth, chlorophyll content, leaf curvature and proline content. Previous studies involving flooding, exogenous ethylene treatments and proline accumulation indicated that flooding damage in tomatoes is caused by the primary effect of oxygen restriction rather than the secondary effect of elevated ethylene levels in the tomato plant.

AVRDC scientists are studying the physiological mechanisms of the tomato fruiting process to pinpoint additional areas for cultivar improvement.

CHINESE CABBAGE

Introduction

Chinese cabbage is one of the most widely grown vegetable crops in Asia's temperate regions. Cultivation in tropical zones, however, is traditionally restricted to the highlands where fragile cultivars can be protected from heat and humidity. Since 1973, AVRDC scientists have been working to develop Chinese cabbage lines specifically adapted to the lowland tropics and have met with substantial success. AVRDC adapted lines are now being grown on a commercial basis in Taiwan and Korea, and are undergoing extensive testing prior to release in more than a dozen other locations. Nevertheless, research continues so as to resolve the constraints associated with yield and performance stability, heat and flooding, as well as the many diseases that can threaten a farmer's crop.

Breeding experiments conducted in 1981, for example, demonstrated that four AVRDC lines were high, stable-yielders, often outperforming the standard check by 7 t/ha. Research efforts also concentrated on the study of heat and flood tolerance. Twenty heat tolerant progenies demonstrated significantly higher levels of electrical conductivity (EC) than sensitive progenies of the same cross. Similarly, nine flood tolerant selections were found to contain higher EC levels than a non-tolerant check. This would indicate that heat and flood tolerance characteristics are closely associated - a factor that should assist researchers in developing lines that are tolerant to both constraints.

New problems were observed, however, in the field of pathology. Screenings for turnip mosaic virus demonstrated an apparent loss of resistance in several selections previously rated as resistant. AVRDC pathologists believe that a new strain of the virus is responsible, and this hypothesis will be further investigated in 1982.

Plant Breeding

Cytosterility backcross program

Studies of cytoplasmic male sterility (CMS) as an alternative to the mechanism of self-incompatibility (SI) in Chinese cabbage hybrid production were continued in 1981. Backcrosses were made to incorporate CMS ex. radish into the genetic background of a local heat tolerant cultivar (B 129) and an inbred line (7252-1) with good combining ability but weak SI. In summer 1981, backcross populations of both cultivars were planted with the objective of selecting heat tolerant and disease resistant progenies.

Six heat tolerant progenies were selected from 1800 plants of the B 129 BC_5 family, and an additional seven from 326 plants of the 7252-1 BC_2 family. Chlorotic plants segregated out at the rates of 11% and 15% for the B 129 and 7252-1 backcross families, respectively.

The use of radish as the CMS source for transfer to *Brassica campestris* has been beset by undesirable features including chlorosis and vestigial nectaries. A program has therefore been initiated using CMS stock ex. *Brassica juncea*. The genetic proximity of *B. juncea* to *B. campestris* should theoretically result in a more compatible nuclear-cytoplasmic interaction in the transfer of CMS into selected Chinese cabbage cultivars. The CMS stock ex. *B. juncea* has perfectly formed nectaries and no evidence of chlorosis.

The incorporation of cytoplasmic male sterility into AVRDC Chinese cabbage lines is being used to develop heat tolerant and disease resistant hybrids.

Commercial production of AVRDC hybrid 58 in Taiwan.

Yield trials

Four AVRDC Chinese cabbage hybrid selections (80-32, 80-33, 80-37 and 80-38) showed promising, high, stable-yields of 25-26 t/ha versus 19-21 t/ha from three local checks in three successive advanced yield trials. AVRDC check hybrid 62 yielded 25 t/ha. The advanced trials continue to show that performance stability during the summer season can be attributed primarily to levels of heat tolerance (measured by heading rate) and harvest rate. Stable entries had heading rates of nearly 100%, and 95% to 99% of the heads were harvested. Harvest rates of less than 87% were attributed to softrot.

Combining ability trials

Three new Chinese cabbage hybrid combinations proved promising after good performances in two combining ability trials in 1981. Although none of the combinations (81-29, 81-39 and 81-44) was superior for any specific character measured, all were marked by consistently high yields and good agronomic characteristics in both trials.

Promising Chinese cabbage hybrid combinations from two combining ability trials

Entry	Marketable yield (t/ha)	Heading rate (%)	Harvest rate (%)
81-29	23.5	100	98
81-44	23.3	100	100
81-39	24.2	100	100
Hybrid 58 (check)	23.7	100	100
Mean of 48 entries	19.0	99+	98

Pathology

Turnip mosaic virus (TuMV) resistance screening

Sixteen Chinese cabbage accessions which rated resistant to TuMV in a 1980 screening (AVRDC Progress Report 1980) were rescreened in spring and fall, 1981. Only one accession (B 730) remained resistant (1%-25% disease incidence) in both 1981 screenings. Accession B 742 rated resistant in the spring screening and moderately resistant (26%-50% disease incidence) in the fall screening, and B 729 was moderately resistant in both screenings. All other accessions rated susceptible or moderately susceptible in at least one screening.

Of 27 breeding lines and F_1 hybrids that rated resistant in a 1980 screening, nine lines remained resistant. A total of 73 early generation inbred lines and advanced lines were subjected to a first screening for TuMV resistance in the fall of 1981. Fourteen lines were rated resistant and will be rescreened in 1982.

Turnip mosaic virus symptoms in a susceptible Chinese cabbage cultivar.

Turnip mosaic virus strain detection

In screenings for turnip mosaic virus resistance, an apparent 'loss' of resistance was noted in Chinese cabbage cultivars previously rated as resistant. In recent screenings, materials that had been used as resistant checks rated only moderately resistant (21%-40% disease incidence) or even susceptible (>75% disease incidence) when artificially inoculated with an isolate of TuMV propagated on *Brassica juncea*. The presence of other TuMV strains is suspected of masking the results of the previous screenings. Preliminary findings have indicated at least two TuMV strains in AVRDC fields.

Screening for resistance to softrot

Twenty-two Chinese cabbage accessions, three breeding lines and hybrids 58 and 59 were rated resistant (1%-20% disease incidence) to softrot (*Erwinia carotovora*) in the spring season. AVRDC hybrid 59 appears particularly promising, having twice been rated resistant and once moderately resistant to TuMV in three successive screenings.

Screening for resistance to downy mildew (*Peronospora parasitica*)

Four Chinese cabbage breeding lines (77M (3)-27S-33, 77M(3)-27B-33, Ping Luh Sib 1 and Ping Luh Sib 2) which were rated resistant to both TuMV and softrot in 1980 screenings, and accession B 742 which was rated highly resistant to downy mildew (AVRDC Progress Report 1980), were screened for downy mildew resistance in spring 1981. Resistance ratings were based on disease incidence. The breeding lines were rated moderately susceptible except Ping Luh Sib 1, which was rated susceptible. Accession B 742 was again rated highly resistant (0% disease incidence) and appears promising after twice rating resistant, once moderately resistant and once moderately susceptible in softrot resistance screenings, and resistant and moderately resistant in TuMV resistance screenings.

Unlike the cultivar shown above, AVRDC Chinese cabbage hybrid 59 is capable of withstanding the damage caused by softrot.

Entomology

Aphid control for Chinese cabbage

The aphid (*Rhopalosiphum pseudobrassicae*) is a serious pest of Chinese cabbage, weakening the plant through direct feeding and serving as a vector for turnip mosaic virus. Screenings for aphid resistance have identified only one resistant Chinese cabbage relative, *Brassica juncea*, but this species carries undesirable traits including non-heading plant type and thick, waxy leaves.

Various cultural control methods, including intercropping, mulching and insecticide applications, were therefore evaluated in winter 1981. Aluminum foil or clear plastic mulches gave the best aphid control and resulted in greater yields than the untreated check. The mulches also significantly reduced TuMV disease incidence. Although applications of pirimicarb 25 WP or prothiofos 50 EC at 0.5 kg ai/ha effectively controlled aphid infestations, yields from these treatments were significantly smaller than those from the two mulching treatments. Intercropping (58 combinations) was not effective as a means of control.

Aphid control for Chinese cabbage seed production

Greenhouse studies indicated that aphid control is necessary throughout the entire Chinese cabbage growth cycle to obtain satisfactory seed yields. Plants were sequentially infested with 1000 aphids at one to eight weeks after planting. Plants were harvested ten weeks after planting, and data were collected on the number of pods per plant, seeds per pod, 1000-seed weight and seed yield per plant. Aphid infestation within the first three weeks of plant growth significantly reduced pod number. The number of seeds per pod was reduced by all aphid infestation durations, but was most affected in plants infested early in the growth cycle. Infestation as late as the eighth week significantly reduced 1000-seed weight.

An aphid infested Chinese cabbage leaf

Physiology

Heat tolerance studies for Chinese cabbage

Previous studies of Chinese cabbage accessions indicated that heat tolerance was closely linked with high electrical conductivity (EC), chlorophyll content and thick leaves (AVRDC Progress Report 1980). These

characteristics were further studied in 250 F_2 progenies involving 37 crosses between heat tolerant and heat susceptible accessions. A total of 20 F_2 progenies selected for heat tolerance had significantly greater EC values, chlorophyll content and leaf thickness than the remaining 230 heat susceptible progenies. The results indicate that selection for heat tolerance may be possible within progenies.

Flood tolerance studies for Chinese cabbage

Nine Chinese cabbage accessions and three F_1 hybrids (58, 59 and 62) were rated flood tolerant when screened in an aerated water culture. Two mM dinitrophenol was added to the solution to mimic soil flooding by blocking oxidative phosphorylation. Tolerance ratings were made on the basis of shoot growth and proline accumulation.

In field screening for flood tolerance, hybrids 58, 59 and 62 yielded 16-17 t/ha after being subjected to 431 mm rainfall (75% of which occurred over a five-day period) during the summer cropping season. Seven accessions, previously rated as flood tolerant, produced yields ranging from 9.8 t/ha to 12.9 t/ha. Flood and heat sensitive accessions B 6 and B 14 yielded 0 t/ha and 4.3 t/ha respectively.

All flood tolerant cultivars showed high electrical conductivity in an evaluation of morphological and physiological characteristics. Except for the three hybrids, all entries also had thick leaves. Together with data from heat tolerance studies, the results suggest that flood tolerance and heat tolerance are closely linked.

Chinese cabbage flood tolerance studies

SWEET POTATO

Introduction

AVRDC chose to work on sweet potato for its excellent nutritional properties and high yield potential. Since the initiation of the Center's sweet potato program, advances have been made in a number of areas, including the development of an early maturing, dessert-type sweet potato with high β-carotene content. Beginning in 1980, however, the program shifted its priorities to the breeding of selections that can meet consumer requirements in Asia for a high protein, high dry matter sweet potato.

AVRDC scientists recognize that the undertaking of this project is not without its complexities. Because sweet potato is vegetatively propagated, for example, its stability varies under different environments and thus requires extensive multi-location testing. This, in turn, is complicated by the quarantine laws in many countries that prohibit the importation of vegetatively propagated crops (see Genetic Resources and Phytosanitation). Nevertheless, full scale research is underway and many of the problems that the program faces are being dealt with systematically.

This past year, for instance, Center physiologists refined a technique for the *in vitro* micropropagation of sweet potatoes that will help to ensure the program's ability to distribute disease-free planting materials. In addition, a series of trials were conducted to screen newly acquired germplasm accessions as well as the Center's

Sweet potato cross pollination

established collection. These trials identified a number of lines with useful characteristics such as high yield, substantial dry matter content and flooding tolerance. Similarly, research is underway to ensure that appropriate technologies are available when new breeding lines with desirable characteristics are ready for testing. These include management practices to control weevils as well as the use of mycorrhizae for sweet potato grown on marginal soils.

Plant Breeding

Yield trials

Breeders continued to identify sweet potato lines in 1981 with good performance in the wet (spring-summer) and dry (fall) seasons. All trials received 20 kg P/ha and 45 kg K/ha (soil incorporated) at planting, and 30 kg N/ha and 45 kg K/ha (side-dressed) 45 days after planting.

In fall season observation trials, 2880 genotypes that produced fleshy roots from true seeds were selected for evaluation. Ten percent of the entries yielded more than 25 t/ha, compared with a mean yield of 14.2 t/ha for all entries. In the advanced trials, eight lines that yielded more than 20 t/ha were selected for further evaluation.

In spring preliminary yield trials, AVRDC selections produced marketable yields of up to 12.7 t/ha, versus 1.7 t/ha for local check cultivar, Tainung 62. A high percentage of cull roots was attributed mainly to excessive soil moisture and partially to excessive vine growth which retarded the development of fleshy marketable roots. Lines with marketable yields of more than 4 t/ha were selected for further wet season evaluation.

In summer preliminary yield trials, selection AIS 995-23 showed promise as a dessert-type sweet potato with a yield of 19

t/ha, 9.7 mg β-carotene/100 g fresh weight and 7% crude protein on a dry weight basis.

In advanced yield trials over two summer seasons, selection AIS 942-26 produced an average marketable yield of 21.8 t/ha with a 25% dry matter content. It is the most promising line yet identified for wet season plantings.

Low sugar crosses

Efforts to identify and develop low sugar sweet potato breeding lines continued in 1981. Results from two preliminary yield trials conducted in dry and wet seasons indicated that high yielding, low sugar lines will be difficult to obtain using conventional sweet potato breeding methods. Progenies derived from open-pollination or polycrosses between low sugar parents were not significantly better than their parental lines in terms of sugar content and yielding ability. Recurrent selection for these characteristics will be used in an effort to concentrate alleles into some of these genotypes.

In March 1981, AVRDC was the co-host of the First International Symposium on Sweet Potato. Attracting more than 100 scientists from 24 countries, the symposium sought to establish the current state of research on this important food crop.

Entomology

Screening for resistance to sweet potato weevil

Nine sweet potato entries showed high levels of resistance to sweet potato weevil (*Cylas formicarius*) and yielded more than 15 t/ha in single screenings at AVRDC and on Penghu Island in the Taiwan Strait. At AVRDC, test materials were planted between heavily infested source rows of a susceptible cultivar. At Penghu Island, weevils were released in the experimental field two months after planting. Evaluation of resistance was based on the number of insects per unit weight of root. Accessions I 152 and I 123, which rated moderately resistant

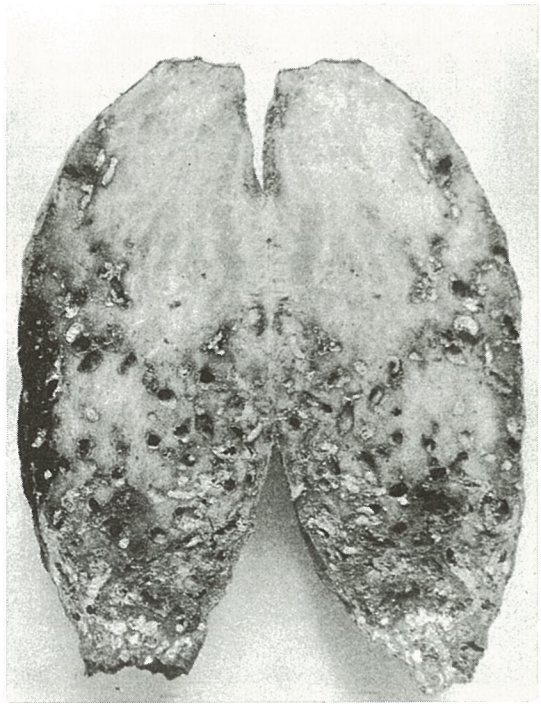
in screenings until 1980 (AVRDC Progress Report 1980) demonstrated only variable resistance.

Cultural control of sweet potato weevil

Effective control of sweet potato weevil was obtained in a three-season experiment involving rice crop rotation. Two fields were selected, one located near weevil-infested fields, and the other at least 0.5 km from any weevil source. Sweet potato cultivar AIS 35-2 was planted in both fields in October 1979, and weevils were released when plants were six to eight weeks old. After harvest, both fields were flooded and planted to rice. After the rice harvest, sweet potato was planted again with four treatments: dipping the cuttings in a 0.1% ai carbofuran 75 WP solution before planting, monthly or biweekly carbofuran 3G soil applications at 2 kg ai/ha, and an untreated control. Dipping the cuttings in carbofuran prior to planting controlled the weevils effectively if the crop was planted away from a weevil source. Both carbofuran soil application treatments controlled the weevils effectively regardless of the proximity of the weevil source.

Analysis of carbofuran residues

Carbofuran 3G at 2 kg ai/ha once every three weeks was the most economical treatment for effective weevil control in a 1980 screening (AVRDC Progress Report 1980). In 1981, the experiment was repeated at AVRDC and at Penghu Island to confirm these findings and to measure the carbofuran residues resulting from the applications. Broadcast applications of carbofuran granules at 2 kg ai/ha again proved to be the most economical, leaving residues of 0.02 ppm at AVRDC and 0.09 at Penghu Island, well below the 1 ppm tolerance limit set by the U.S. Environmental Protection Agency.



Cultural controls and sanitation hold the greatest promise of minimizing the losses associated with sweet potato weevils.

In the Penghu Island trials, the insecticide treatments were also evaluated for control of stemborer (*Omphisa illisalis*). Carbofuran applications of 2 kg ai/ha at one, two, three or four-week intervals gave good stemborer control and resulted in significantly greater yields than any of the other treatments.

Screening for resistance to stemborer

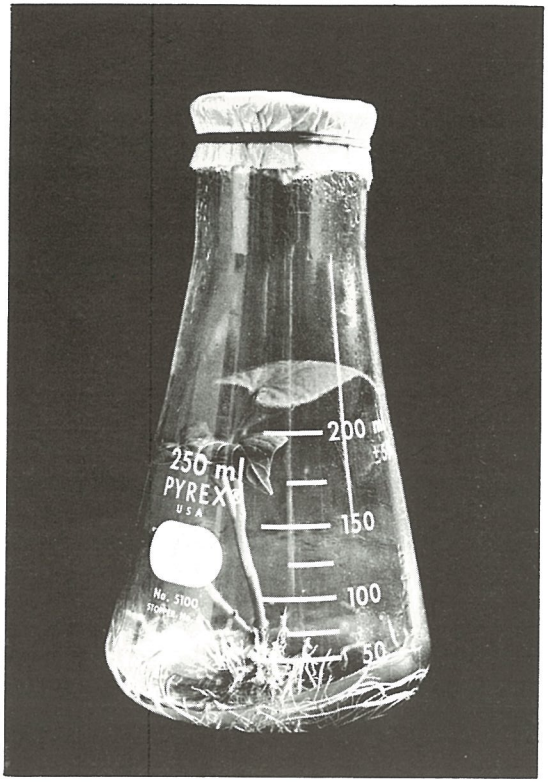
Sweet potato accessions I 55 and I 92 were previously identified as having high levels of resistance to stemborer (*Omphisa illisalis*). These accessions were rescreened in 1981 with susceptible selection AIS 35-2 in an eight replication experiment. Four replicates were treated biweekly with carbofuran 3G at 2 kg ai/ha, and the remaining four replicates were left untreated. Both I 55 and I 92 showed significantly less damage than AIS 35-2 when stemborer was not controlled. Insecticide treatments significantly reduced stemborer damage in AIS 35-2, but not in I 55 and I 92. Yield increases resulting from the insecticide treatments were highly significant (1% level) for AIS 35-2, significant (5% level) for I 92, and insignificant for I 55. Stemborer damage and root yield were significantly negatively correlated (1% level) in AIS 35-2, and insignificantly correlated in I 55 and I 92, confirming the stemborer resistance of the two accessions.

Flood tolerance trials

Physiology

Effect of flooding on growth and yield of sweet potato

Field and greenhouse trials were conducted with AVRDC sweet potato selections AIS 0122-2 and AIS 35-2 in an attempt to separate the effects of flooding from those of high temperature, both of which combine to reduce yields in the hot-wet summer season. Both



The tissue culturing of vegetatively propagated crops such as sweet potato will be used to supply national programs with disease-free planting materials.

cultivars were planted during the cool dry season and subjected to five days of artificial flooding at 46 days after planting. At 73 days after planting, the flooded cultivars showed reduced storage root number and mean storage root weight. At harvest, the flooded treatments produced lower yields of tips and roots than the non-flooded control. These preliminary result suggest that low sweet potato yields in the hot-wet season may be due more to excessive moisture than to high temperature.

VA mycorrhizae and sweet potato growth

Greenhouse and field experiments were conducted to evaluate . inoculations of vesicular arbuscular mycorrhizae on sweet potato, a treatment which may have potential for sweet potato grown on marginal lands. Cuttings of sweet potato selection AIS 0122-2 were planted in plastic posts of sterilized soil. Four fertilizer treatments (N, NP, NK and NPK) were applied alone or combined with VA mycorrhizae inoculations (500 g *Glomus fasciculatus* inoculum/pot). VA mycorrhizae inoculations significantly improved sweet potato growth in sterilized soil regardless of fertilization, whereas non-inoculated plants suffered poor growth regardless of fertilization. In the field experiment, sweet potato was planted in a no-tillage rice-stubble field with the following treatments: 1) mycorrhizae inoculation only, 2) P fertilization only, 3) both inoculation and fertilization and 4) no inoculation or fertilization. There was no significant response in tip or storage root yields in any of the treatments.

MUNGBEAN

Introduction

AVRDC's mungbean research program emphasizes the development of high yielding, stable lines with uniform maturity, good seed quality, wide adaptability and multiple disease and insect resistance. As a result of this research, AVRDC-developed lines have been released to farmers in Costa Rica, Korea and Taiwan. Perhaps more important, Center selections have been used to develop locally adapted cultivars in such diverse locations as Australia, India, Indonesia, Malaysia, Thailand and the islands of the South Pacific.

Despite the progress already made, AVRDC recognizes it has yet to realize the mungbean's full potential. Center scientists now believe that the yield threshold of mungbean is somewhere in the vicinity of 3 t/ha, even though most farmers harvest well below 1 t/ha. At the present time, AVRDC lines are producing 1.5 to 2 t/ha with some selections gradually approaching the 3 t/ha threshold. These results were confirmed in 1981 trials where the mean yield for 30 AVRDC entries was 2 t/ha, with selection V 2764 producing a high yield of 2.6 t/ha. In addition, VC 1973 A, one of AVRDC's earlier breeding lines, produced average yields of 1.5 t/ha in multi-location tests conducted in five countries (see International Mungbean Nursery).

The full promise of AVRDC mungbeans will not be met, however, unless selections are also developed with resistance to insects

and diseases. For this reason, a major effort is underway to develop resistant or tolerant lines that can be incorporated with high yielding breeding stocks. Line VC 1560 D, for example, has demonstrated high levels of multiple disease resistance to both *Cercospora* leafspot and powdery mildew. Similary, 25 F_4 lines have been selected for their beanfly resistance and are now scheduled for advanced multi-location testing.

Plant Breeding

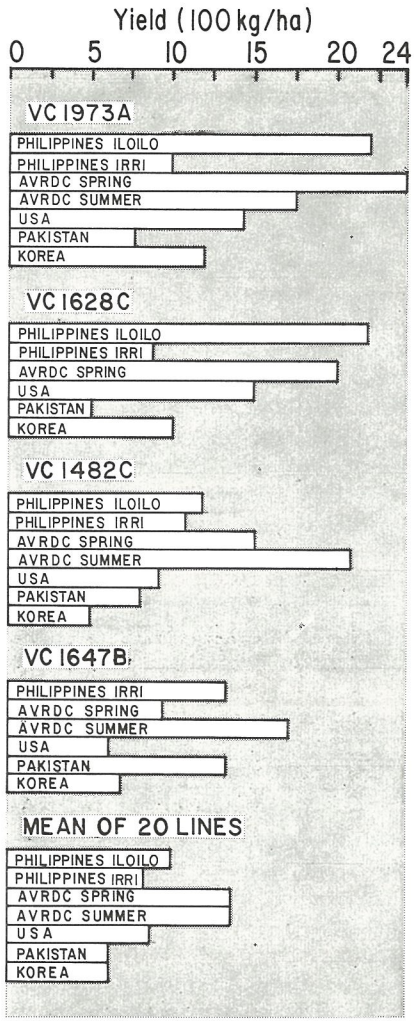
Yield trials

The average spring yield for 30 AVRDC elite mungbean breeding lines was 2.0 t/ha compared with 1.7 t/ha from check cultivar V 3476. Breeding line VC 2764 A yielded highest at 2.6 t/ha. In a summer trial of the same elite lines, the mean yield was 1.7 t/ha compared with 1.5 t/ha from check V 3476. Line VC 1482 D was the highest yielding entry at 2.1 t/ha.

In advanced yield trials, 1.9 t/ha was produced by two AVRDC breeding lines in spring and by four lines in summer, compared with check cultivar V 3476 at 1.6 t/ha in spring and 1.4 t/ha in summer.

Identification of mungbean lines with resistance to *Cercospora* leafspot (CLS) and powdery mildew (PM)

Eleven advanced AVRDC mungbean breeding lines demonstrated moderate to high levels of resistance to both *Cercospora* leafspot (*Cercospora canescens*) and powdery mildew (*Erysiphe polygoni*) during the spring, summer and fall cropping seasons. Ten lines were rated highly resistant to CLS only, and 15 lines were highly resistant to PM only. Plants were exposed to natural powdery mildew epiphytotics or inoculated with *Cercospora* leafspot for the CLS resistance screenings. Lines showing higher levels of resistance than accession V 2773 (moderately resistant to both



AVRDC mungbean breeding lines were the highest yielders in 1981 International Mungbean Nursery trials conducted at six locations in five countries. Selection VC 1973 A had the highest average yield of 1.5 t/ha at all locations.

diseases) were rated highly resistant, whereas those with similar levels were rated moderately resistant.

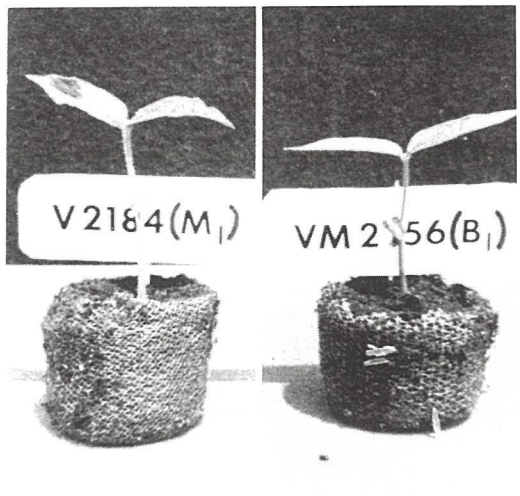
Breeding lines VC 1560 D and VC 2719 A rated highly resistant to both CLS and PM, and produced higher yields with better agronomic characters than V 2773 and other moderately resistant accessions. V 2773 was the disease resistance source for both cultivars, indicating that levels of resistance can be enhanced through intercrossing. These two lines will be used as sources of disease resistance in the mungbean crop improvement program.

Photoperiod sensitivity evaluations for mungbean

Sixty-two advanced AVRDC mungbean breeding lines demonstrated photoperiod insensitivity in a fall season screening. A total of 281 lines were exposed to artificial 16 hr photoperiods and natural daylength (avg. 12 hr). The difference in days-to-flowering between photoperiod treatments was less than four days in 62 lines, five to eight days in 116 lines, nine to 16 days in 99 lines, and 17 to 24 days in four lines. This would indicate that the majority of these lines can perform under a variety of photoperiods.

Interspecific hybridization for mungbean improvement

Blackgram (*Vigna mungo*) is closely related to mungbean (*Vigna radiata*) and has many of the attributes desired for mungbean — resistance to major mungbean diseases and pests, high methionine content, shattering resistance and a long beansprout shelf life. Attempts have been made to transfer these characters to mungbean through interspecific hybridization, but high sterility rates (86-97%) indicate that a direct gene transfer from blackgram to certain mungbean lines will be difficult. AVRDC researchers are now focusing their efforts on identifying interme-



Interspecific hybridization is being used to incorporate the desirable traits of blackgram (left) into mungbean (right). These characteristics include resistance to insects, diseases and shattering, as well as high methionine content.

diate-type mungbean lines from the germplasm collection which can be used as a genetic 'bridge' for the transfer of target characters to selected mungbean lines.

AVRDC Director G. W. Selleck examining line VC 1560 D - a selection with multiple resistance to Cercospora *leafspot and powdery mildew.*

Pathology

Epidemiology of *Cercospora* leafspot (CLS)

In a study to evaluate the development of a CLS epidemic and the nature of mungbean CLS resistance, breeding line VC 1560 D and accession V 4718 rated most resistant on the basis of disease development rates. The study involved four accessions and three breeding lines that were rated resistant to CLS in a 1980 screening. In all three breeding lines, the rate of disease development was usually less and never more than that of the resistant parent used in the cross, indicating that even higher levels of resistance are attainable through crop improvement. Similar to results observed in 1980, the CLS epidemic developed late in the season and caused no significant yield loss in any of the cultivars including susceptible accession V 2010.

The results also showed a highly significant correlation between total lesion number per plant and the rate of CLS development, suggesting that lesion number at the beginning of an epidemic could be used to predict the rate of CLS development in breeding lines relative to that of a check cultivar.

Characterization of CLS development on CLS resistant mungbean

The number and size of *Cercospora* leafspot (CLS) lesions should prove useful in identifying mungbean cultivars with rate-reducing resistance to CLS. Breeding line VC 1560 D (CLS resistant) and accession V 2010 (CLS susceptible) were planted in the field and exposed to naturally occurring CLS pressure. Lesion number increased with time

in both cultivars, but the rate of increase for VC 1560 D was less than 40% that of V 2010. Average lesion diameter increased with time in the susceptible cultivar, but increased at a slower rate in the resistant cultivar. The results indicate that VC 1560 D is not only resistant to infection, as indicated by a reduced rate of lesion number increase, but also to individual lesion development.

Control of the mungbean root disease complex

The mungbean root disease complex which severely damaged crops in 1979 and 1980 was effectively controlled in fall 1980 with chloropicrin. All plants received rhizobium inoculations to ensure nodulation, and some plants were inoculated with *Glomus fasciculatus* to evaluate the effect of the root disease complex on mycorrhizal associations (AVRDC Progress Report 1980).

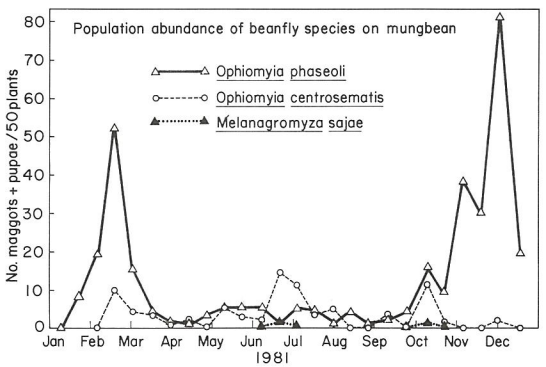
The residual effects of the fumigation and inoculations were significant in a subsequent mungbean crop in spring 1981. Yield from the previously fumigated plots was more than five-fold that of the non-fumigated plots. There was some recolonization by pathogenic fungi and reniform nematodes in the fumigated plots during the spring planting. Plants in the non-fumigated plots showed stunting, chlorosis and root deterioration, as previously observed in the fall 1980 planting. Mycorrhizae inoculations increased plant height, leaf area and yield only in those plots previously fumigated, indicating that the effect of mycorrhizal associations was reduced by severe mungbean root damage in the non-fumigated plots.

Although chloropicrin was effective in controlling the root disease complex for at least two consecutive seasons, it is not an economical treatment for commercial production. Other control measures such as crop rotation need to be evaluated.

Chloropicrin fumigation was found to effectively control the mungbean root disease complex. While effective in AVRDC experimental fields, a more economical method of control will be required for commercial production.

The beanfly is one of the most serious legume pests in the tropics. Trials conducted in 1981 identified a number of mungbean and soybean selections with potential resistance.

Seasonality of beanfly species on mungbean



Three species of beanfly (Melanagromyza sojae, Ophiomyia centrosematis *and* Ophiomyia phaseoli) *were monitored throughout 1981 to determine their seasonal infestation patterns on mungbean.* O. phaseoli *was dominant, especially during the fall cropping season when beanfly damage is most severe.*

Fungal pathogens involved in the mungbean root disease complex

Five pathogenic fungi (*Macrophomina phaseolina, Rhizoctonia solani, Pythium aphanidermatum, Helminthosporium rostratum, Fusarium roseum*) were isolated from the roots of mungbean plants affected by the mungbean root disease complex. These fungi were inoculated singly and in combination into mungbean plants in greenhouse and field tests. All inoculations caused severe root deterioration, stunted plant growth and typical disease complex symptoms. All of the fungi except *H. rostratum* are known mungbean pathogens.

Entomology

Screening for resistance to beanfly

A total of 25 F_3 mungbean selections, out of a population of 295, was infested with an average of only 15 beanflies/100 plants in a fall screening for beanfly resistance. Each selection was exposed to the prevailing beanfly population, and plants were sampled for beanfly damage at four weeks after planting. The F_4 lines will be tested in 1982 at AVRDC and under heavier population pressure in selected beanfly-infested areas in Thailand and Indonesia.

SOYBEAN

Introduction

Since the early 1970's, AVRDC has sought to improve the production potential of tropical soybean. Center research has stressed the development of improved lines with high, stable yield, early maturity, photoperiod and temperature insensitivity, good seed stock quality and multiple disease and insect resistance. As a result of these efforts, AVRDC soybeans have now been officially released in Honduras, India, Indonesia, Malaysia, Taiwan and the U.S.A. Reports also indicate that a number of new releases can be expected in 1982-83.

Despite these achievements, AVRDC soybean breeders are currently working to develop a new generation of narrow- and broad-leaflet breeding lines with substantially better yield potential. Multi-location trials conducted in 1981 demonstrated that these lines could provide yields in excess of 2 t/ha, with highs of 4.5, 3.9 and 3.6 t/ha recorded in the spring, summer and fall seasons, respectively. A number of lines also showed adaptability across two and three cropping seasons, leading to the belief that AVRDC may soon have available seasonally adapted soybeans that can assist national programs in promoting year-round production in tropical areas.

A major effort was also made this past year to gain new insights into the epidemiology of soybean rust. Studies indicate that the physiologic age of the soybean plant plays an important role in rust development, with later maturing plants 'appearing' more

resistant than those that are early maturing - even if their levels of resistance are the same. This hypothesis is scheduled for further investigation in 1982 and should aid in the development of a new technique for identifying rust resistant lines.

Any attempt to truly 'tropicalize' the soybean, however, will require the concurrent development of selections with substantial levels of insect resistance. Accordingly, AVRDC entomologists are conducting a broad-based program to develop soybeans that can sustain yields even under heavy pressure from insects such as beanflies and podborers. On the basis of this research a number of potentially promising lines have been identified and are slated for advanced testing in 1982.

AVRDC narrow-leaflet soybeans are now providing consistent yields of 2-3 t/ha under tropical conditions. Overall yield potential is considered to be in the area of 4 t/ha.

Plant Breeding

Soybean yield trials

A total of 168 soybean selections were evaluated in spring, summer and fall 1981. Average yields exceeded 2 t/ha in all three seasons, with highest yields of 4.5 t/ha in spring, 2.9 t/ha in summer and 3.6 t/ha in fall. Yields of the preliminary and intermediate soybean yield trials were 2 t/ha or more in all three seasons. The spring intermediate yield trial selections yielding 4.0 t/ha or more also showed multiple disease resistance.

Soybean selections with two- and three-season adaptability

Four AVRDC soybean selections (AGS 129, AGS 146, AGS 154 and AGS 162) demonstrated high stable yields in advanced yield trials over three cropping seasons. Five selections yielded well in two cropping seasons. AGS 154 and AGS 162 showed no symptoms of

downy mildew or bacterial pustule in all three seasons.

Photoperiod studies of advanced yield trial selections

In 1980, advanced soybean selections were rated for photoperiod sensitivity based on the difference in the number of days to flowering between different photoperiods (AVRDC Progress Report 1980). In a 1981 companion study, correlations between these photoperiod sensitivity ratings and yields of the advanced selections indicated that photoperiod insensitivity is significantly correlated with high yields in the summer. In the fall, photoperiod insensitivity was not necessary for high yields, and results for the spring season suggest that photoperiod sensitivity is desirable to obtain high yields.

Trifoliolate leaves and reproductive potential

Further insights were made into the relationship between the number of trifoliolate leaves and reproductive potential of soybean in an evaluation of three photoperiod insensitive accessions and one sensitive accession. Treatments included the stripping of plants leaving zero, one, two, three or four trifoliolates. Days-to-flowering were the same for all photoperiod insensitive accessions regardless of treatment. A reduction to three trifoliolate leaves or less for photoperiod sensitive G 2120 sharply increased the time required for flowering. The insensitive genotypes were more efficient than G 2120 in seed production per unit leaf area.

Vegetable soybean selection

Four out of 140 soybean entries exhibited acceptable vegetable characteristics, including large pods with two or more large seeds per pod, and grey pubescence and hilum.

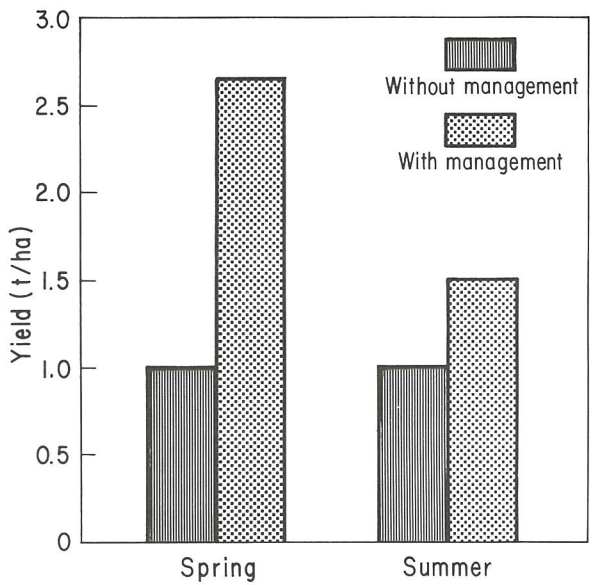
Studies have demonstrated that photoperiod insensitive soybeans can flower even when stripped of trifoliolate leaves (right). This technique is now being used to identify photoperiod insensitive lines in greenhouse experiments.

Taste-testing AVRDC vegetable soybean selections is an important part of the crop improvement process.

The length and width of two- or three-seeded pods were significantly correlated with 100-seed weight (r = 0.66**).

In evaluations of seven vegetable soybean types, selection AGS 164 produced the highest green bean yield (90% moisture basis) of 10.7 t/ha in the spring cropping season. In the fall cropping season, G 8285 yielded 17 t/ha. In a three-season trial, AVRDC vegetable soybean selections AGS 164, AGS 165 and AGS 167 significantly outyielded checks Zen Wu No. 2 and Tzurunoku in all three seasons. These improved lines are now being tested in several countries.

Soybean response to maximum and minimum inputs



A study of 14 soybean genotypes under both maximum and minimum input conditions confirmed previous findings that management is a major constraint to high yields in the spring cropping season. In the summer cropping season, the selections were less responsive.

Paraquat sprayings to hasten soybean maturity

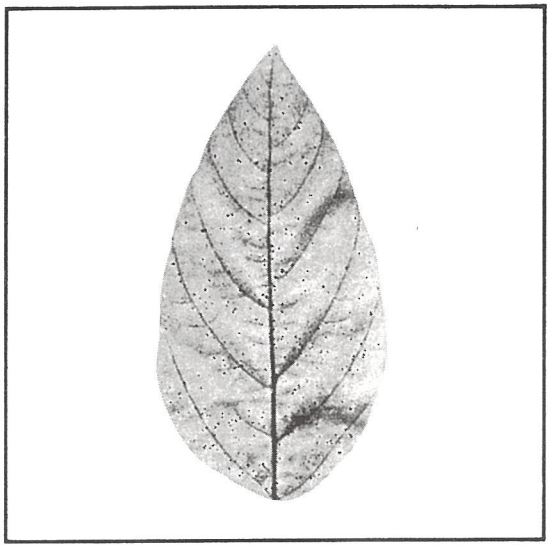
In the wet summer season, paraquat was tested for its ability to hasten soybean maturity, thereby avoiding rain damage at harvest. Paraquat at 0.84 kg/ha ai was sprayed at the R6, R6.5 or R7 growth stages of three soybean cultivars. Control plants were not sprayed. Results indicate that paraquat applied at stage R6 can advance soybean harvests by as much as two weeks. A yield reduction of up to 34% occurred, versus a total crop loss due to rainfall at the normal harvest time. This technique should thus permit an additional generation of breeding lines each year.

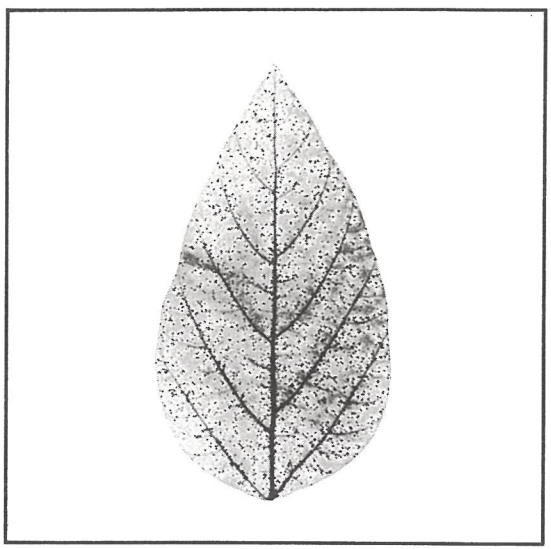
Pathology

Physiologic age of soybean and soybean rust development

Physiologic age of a soybean plant, as expressed by days to full maturity (DFM), plays an important role in the rate of soybean rust (*Phakopsora pachyrizi*) development. Two soybean cultivars were grown under natural photoperiods (avg 11.2 hr) and 14 hr photoperiods. Both cultivars matured later under the 14 hr photoperiods. When rust development was analyzed using days after planting (DAP) as a parameter, both cultivars showed significantly higher disease development rates under the shorter photoperiods. However, when adjustments were made for the different maturities under the different photoperiod regimes, there were no significant differences in disease development rates between photoperiod treatments for either cultivar.

Since the rate of rust development decreases with increasing days to maturity in the same cultivar, late-maturing cultivars would appear to have higher levels of resistance when compared with early-maturing cultivars, even though their actual levels





The physiologic age of the soybean plant plays an important role in the rate of soybean rust development. The leaf of a later maturing plant (above) appears less infected than the leaf of an earlier maturing plant (below), even though the levels of rust resistance of both plants are the same.

of resistance may be similar. Future rust resistance screening efforts should therefore evaluate lines and check cultivars that have been selected first by maturity group.

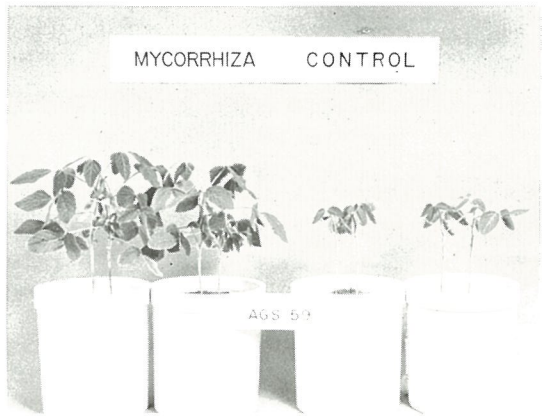
Rust resistance in advanced soybean breeding lines

Seventeen advanced soybean breeding lines and three check cultivars were evaluated from October to December 1981 for the rate of rust development and the relative level of resistance for each cultivar. Rust development rates were calculated by linear regression based on disease severity (expressed by logit) and relative time [(days after planting) ÷ (days to full maturity) x 100]. Relative time was used to partially correct for differences between cultivars in days to maturity.

Although initial rust infection occurred late in the season, several cultivars appeared to be distinctly more resistant than check cultivars Taita Kaohsiung No.5, Shih Shih and Tainung No. 4.

Mycorrhizae and rice-rice-soybean cropping systems

Soil samples from a rice-rice-soybean field were collected at two growth stages of soybean and analyzed to assess the population dynamics of mycorrhizae in a rice-rice-soybean cropping system. Soil sampling sites were randomly selected from two fields, and mycorrhizal spores were extracted by both centrifugation in sucrose and a wet-sieving/decanting technique. A total of 12 species of four genera were identified from the two fields. *Glomus etunicatus* and *G. macrocarpus* var *geosporus* were the predominant mycorrhizal fungi in both fields. The results show field survival of numerous mycorrhizal fungi spores following two successive paddy rice crops. The mycorrhizal associations formed with soybean by these indigenous species will be assessed in 1982.



Mycorrhizae inoculations have been shown to promote soybean growth in pot experiments. Significant yield increases have also occurred in field experiments following rice *(see p. 38).*

Interaction of mycorrhizae and soybean mosaic virus (SMV) in soybean

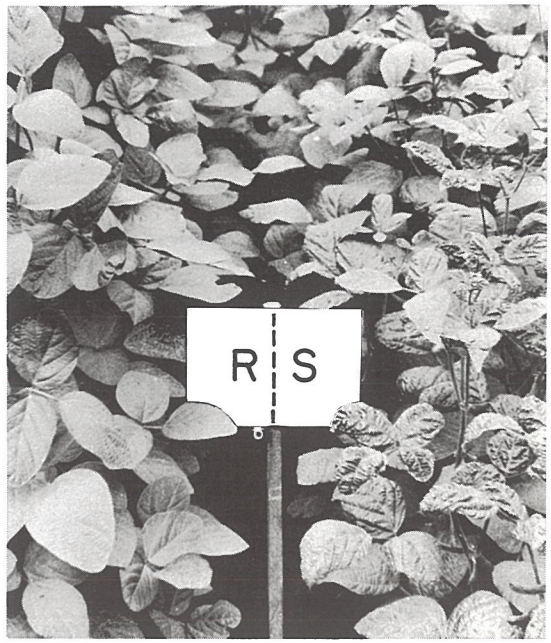
The interaction of mycorrhizae and SMV in soybean was assessed in a pot experiment comprising four treatments: SMV inoculation of the soybean plant at the cotyledon (VC) growth stage, mycorrhizal inoculation at planting together with SMV inoculation at the VC stage, mycorrhizal inoculations alone, and the non-inoculated control. Inoculated with SMV alone, the virus significantly reduced plant height, 100-seed weight and leaf area (sixth node), compared with the non-inoculated control. In plants inoculated with both SMV and mycorrhizae, the virus infection significantly reduced only the 100-seed weight and area of the sixth node leaf. However, all yield components of the mycorrhized plants, regardless of virus infection, were equal to or higher than those of the non-inoculated controls.

SMV identification and strain detection

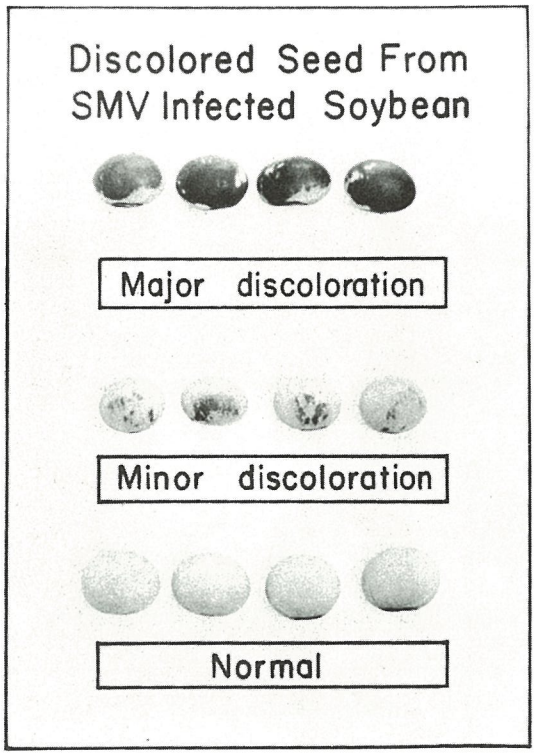
A total of 107 soybean samples with mosaic, mottle or necrosis symptoms were collected from major soybean growing areas in four counties in Taiwan. Samples were assayed on detached leaves of *Phaseolus vulgaris* cv. Topcrop, the local lesion host for SMV. On the basis of differential host reactions and electron microscopy examinations, ten samples were shown to contain SMV. Three isolates from these samples were positively identified as strain SMV-G-1, and one isolate was tentatively identified as strain G-3. The remaining six isolates did not conform to any of the seven known SMV strains.

Screening for resistance to soybean mosaic virus (SMV)

A total of 168 breeding lines and some parental lines were evaluated for the first time in the greenhouse for resistance to soybean mosaic virus. Fifty plants of each



A soybean mosaic virus susceptible line (right) growing side by side with an improved, resistant selection (left).



Seed discoloration was found to have a link to the transmission of soybean mosaic virus. Seeds with the most discoloration had transmission rates of 10% to 18%, whereas those with less discoloration had significantly lower rates.

line were inoculated at the primary leaf stage with SMV-strain 1. Lines without symptoms were back-inoculated to *Phaseolus vulgaris* cv. Topcrop (the local lesion host for SMV) to check for symptomless infection and immunity. Five lines (AGS 9, AGS 19, AGS 129, AGS 147 and AGS 103) were immune to SMV-1, and five lines (AGS 112, AGS 114, AGS 115, AGS 116 and AGS 166) rated resistant.

Intensity of seed discoloration and seed transmission of SMV

The intensity of seed discoloration was found to be related to seed transmission of soybean mosaic virus (SMV). Seed harvested from SMV-1 infected soybean plants were grouped into six classes by size and color and immediately sown. The emerging seedlings were observed for SMV symptoms. Seeds with the most intense discoloration (dark black and dark brown) extending beyond the seed shoulder had high SMV transmission rates (18% and 10% respectively), whereas seeds with light grey or light brown discoloration had transmission rates of 1.8% and 1.7%, respectively. No transmission was obtained from seeds without discoloration.

Entomology

Screening for beanfly tolerance in soybean

Six soybean accessions exhibited tolerance to beanfly infestations in a fall screening. Each entry was planted in two plots, one of which was kept beanfly-free with monocrotophos applications and one which was allowed to become infested with beanflies. Mean yield reduction for 200 entries was 16.2%. For accessions G 64, G 123, G 135, G 212, G 222 and G 252, beanfly infestations reduced grain yields by less than 1% of those from the beanfly-free treatments. The tolerance of these six accessions will be reevaluated in 1982.

Chemical control of beanfly

In previous insecticide screenings, only monocrotophos, dimethoate and omethoate provided effective control of beanflies on soybean. Since these organophosphorus insecticides are chemically similar, it is possible that beanfly resistance to one will render the others ineffective. Six new insecticides were thus screened in fall 1981 as alternatives. None of the insecticides controlled beanfly as effectively as monocrotophos or omethoate. Carbicron and chlorpyriphos controlled beanfly for three weeks after germination, but not long enough to prevent economic loss. These insecticides will be reevaluated in fall 1982 trials.

Screening for resistance to podborer

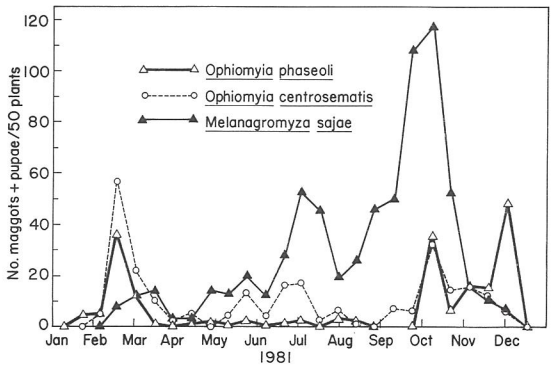
Soybean accession G 8506, which appeared moderate to highly resistant to podborer (*Etiella zinckenella*) in tests at AVRDC, was the least affected entry (33.5% mean damage) under high podborer pressure at three locations in Indonesia. Mean damage for the susceptible checks ranged from 50.1% to 61.6%. Accessions G 8506 and G 8448 (41.7% mean damage) are now included in the soybean crop improvement program to develop podborer resistant lines.

Physiology

Mycorrhizae and phosphorus uptake

To assess previous indications that the infection of soybean roots by vesicular-arbuscular mycorrhizae is influenced by soil-available phosphorus concentrations, soybean cultivars G 2 and AGS 66 were grown with and without mycorrhizae (*Glomus fasciculatus*) inoculations in soils at two available P levels. Mycorrhizae inoculations increased both total dry weight and shoot P content, especially under the higher available P lev-

Seasonality of beanfly species on soybean



Three species of beanfly (Melanagromyza sojae, Ophiomyia centrosematis *and* Ophiomyia phaseoli) *were monitored in 1981 to determine their seasonal infestation patterns on soybean.* M. Sojae *was dominant, especially during the fall cropping season when beanfly damage on soybean is most severe.* O. centrosematis *was dominant in the spring, but beanfly infestations during this season do not cause significant damage to soybean at AVRDC.*

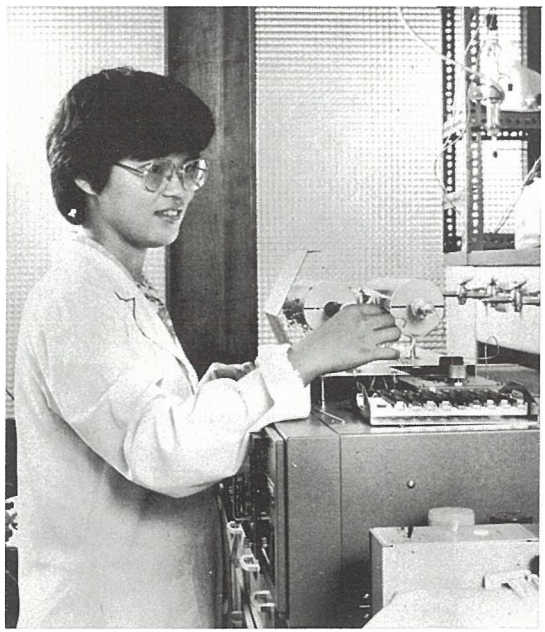
el (about 22 ppm). Acid phosphatase activity was also significantly higher with mycorrhizae inoculations. Mycorrhizae can thus enhance P uptake, most likely by converting non-available P to its available form.

Mycorrhizae and no-tillage rice-stubble soybean

Field trials were conducted in fall 1981 in a continuing evaluation of vesicular-arbuscular mycorrhizae on no-tillage rice-stubble soybean. Fields were inoculated with *Glomus fasciculatus* at 15 g/rice stubble after the rice harvest. Soybean selection AGS 2 was planted using all standard AVRDC cultural practices except the application of phosphorus. VA mycorrhizae inoculations increased the yield by 11% over that of the non-inoculated control.

Planting no-till-rice-stubble soybean.

Nutrition, Environment and Management

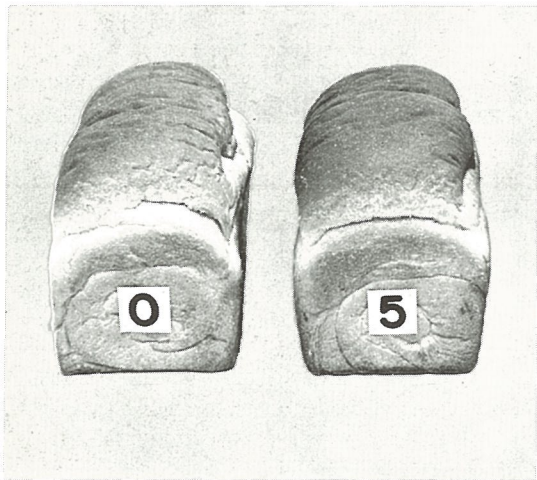


Introduction

The objective of AVRDC's Nutrition, Environment and Management Program (NEM) is to expand the potential and utilization of AVRDC-developed cultivars. The broadest of all of the Center's research programs, NEM encompasses such disciplines as nutrition chemistry, soil science, crop management, agricultural economics and social anthropology.

Despite this diversity, NEM scientists are pursuing a series of studies that are closely coordinated with the Center's other research programs. In the field of nutrition chemistry, for example, mass screening methods have been developed to assist AVRDC's crop improvement programs assess recently acquired germplasm accessions and newly developed selections for desirable nutrient qualities. These include an *in vitro* sweet potato eating quality test to replace organoleptic tests and an *in vitro* mungbean protein digestibility test. Both procedures are expected to reduce the time required to assess the composition of target crops and accelerate the incorporation of desirable characteristics into advanced breeding lines.

Progress has also been made in the development of garden technologies for nutrition intervention programs. Preliminary trials in 1981 demonstrated that small-scale gardens can provide substantial amounts of vitamins and minerals to the diets of the rural poor. A case in point is the home garden. Designed for use in Southeast Asia,



Bread made with 5% protein-rich mungbean fractions (right) compares favorably to a control loaf (left) in terms of mixing tolerance, volume and consumer acceptability.

this 4 x 4 m garden was shown capable of providing a family of five with its minimum daily requirements for calcium, iron and Vitamins A and C during an average 90 day growing season.

NEM disciplines such as crop management and soil science also play important roles in meeting AVRDC research objectives. For example, bed height experiments conducted in 1981 demonstrated that farmers can reduce the risk of flooding by utilizing 30 cm high beds instead of traditional 15 cm beds. This technique was shown to significantly increase Chinese cabbage and tomato yields; often transforming no yield results into profitable production. Progress was similarly made in maximizing the benefits associated with chemical fertilizers. Trials conducted by AVRDC soil scientists indicated that N fertilizer absorption by Chinese cabbage can be substantially increased by simply switching from single-band to double-band application.

In addition to nutrition and management studies, NEM also features economics and social anthropology units that provide information on general agricultural trends as they relate to AVRDC research. Studies are regularly conducted on such topics as the vegetable soybean industry in Taiwan, vegetable consumption patterns and vegetable farmers' cooperatives. These kinds of studies have played an important role in selecting AVRDC research objectives, and have assisted scientists in keeping abreast of the rapid changes taking place in the agricultural sector.

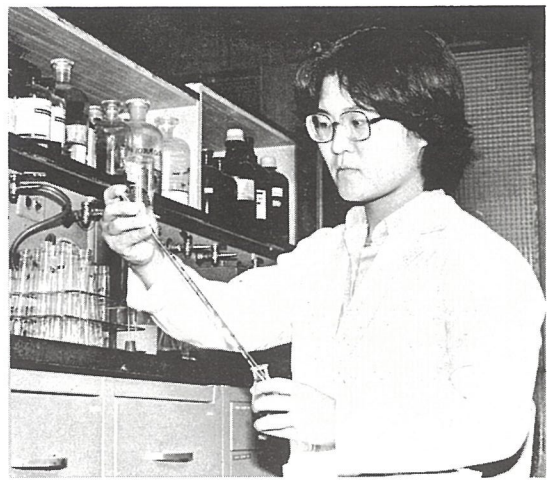
Nutrition Chemistry

Utilization of air-classified mungbean protein

Mungbean starch for starch noodle production has traditionally been extracted in a

wet-milling process which results in the loss of the mungbean protein. Air-classification (a dry process) has proven feasible for producing mungbean starch while retaining the mungbean protein (AVRDC Progress Report 1980). Economic feasibility of the process, however, depends on whether the mungbean protein can be used.

Air-classification was therefore used to produce mungbean protein for fortification of wheat flour bread. Approximately 80% of the original seed protein was recovered in protein-rich fractions (PRF) and in the hull. The PRF was added to wheat flour at the rates of 5%, 10%, 15% and 20%, and breads were prepared. Flour dough with 5% PRF had a significantly higher mixing tolerance than the unadulterated control, and loaf volumes decreased with increasing PRF content. The addition of surfactants such as sodium stearoyl-1 lactylate and potassium bromate increased the loaf volumes of the 5% and 10% PRF-fortified breads to sizes comparable with that of the control. In organoleptic tests, both the 5% and 10% PRF-fortified breads were comparable with, or more acceptable than, the control.



Protein digestibility testing is an integral part of AVRDC's mungbean improvement program.

In vitro test for mungbean protein digestibility

An *in vitro* mungbean protein digestibility test has been developed to replace the traditional *in vivo* animal feeding test which is unsuitable for mass screening work. The test involves monitoring the growth of *Streptococcus zymogenes* $NCDO_{592}$ bacteria in an amino acid-limited medium. The growth of these bacteria is directly proportional to the availability of specific amino acids. Ten amino acids were examined and availability indexes prepared. Valine and leucine were found suitable for mungbean and blackgram protein digestibility determinations. The correlation coefficients between *in vivo* (apparent and true digestibility) and *in vitro* (available valine and leucine indices) tests were highly significant.

Effect of tannin on blackgram protein digestibility

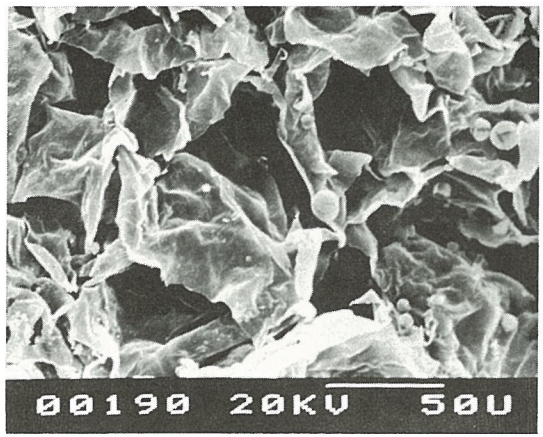
Mungbean's value as a complete protein source is limited because of its low concentration of methionine, an essential amino acid for human nutrition. The methionine content of mungbean can be improved through interspecific hybridization with blackgram (*Vigna mungo*), but the low digestibility of blackgram protein is a major constraint. An animal feeding experiment was therefore conducted to evaluate the relationship between blackgram seed components and protein digestibility. Seed coat tannin was significantly negatively correlated with protein digestibility in both *in vivo* (r = -0.84** for true digestibility and r = -0.79** for apparent digestibility) and *in vitro* tests (r = -0.88** for valine and r = -0.87** for leucine).

Phosphorus content and sweet potato digestibility

The multivalent nature of phosphorus enables it to affect starch granule structures, and the structure of the granule in turn affects starch digestibility. In an experiment to determine the relationship between phosphorus and sweet potato digestibility, the starch of 21 sweet potato lines was analyzed for phosphorus content. Digestibility of the samples was evaluated *in vitro*. There was a highly significant negative correlation between phosphorus content and the digestibility of the sweet potato starch (r = -0.614**).

Sweet potato eating quality

Previous research indicated that sweet potato eating quality (as determined in organoleptic tests) was closely related with the steamed cultivar's content of alcohol insoluble solids. Correlations between alcohol insoluble solids and other chemical components (including dry matter, free su-



Sweet potatoes with high dry matter content are the consumer standard in many parts of Asia. In order to rapidly identify selections with this characteristic, AVRDC nutrition chemists are now using scanning electron microscopy. The photo above, for example, shows a moist sweet potato whose cell walls have collapsed during specimen preparation. The photo below shows a dry selection whose cell walls have remained rigid after the same treatment. These difference should assist researchers in rapidly identifying drier sweet potatoes.

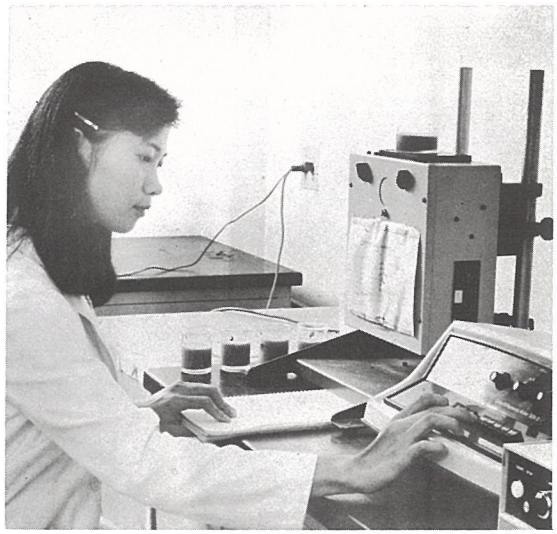
gars, water soluble and insoluble starches, cellulose, hemicellulose, pectic substances and lignin) were sought for possible use in *in vitro* assessments of sweet potato eating quality. Hemicellulose, and water insoluble starch and pectic substances were significantly positively correlated with alcohol insoluble solids, and the correlation between alcohol insoluble solids of steamed and raw sweet potatoes was highly significant ($r = 0.809^{**}$). Raw sweet potatoes can therefore be evaluated *in vitro* to predict eating quality.

Processing tomato quality assessment

Nine advanced processing tomato breeding lines and one check accession (L 387) were planted throughout the summer and fall, harvested on five dates (June, July, August, September and November) and evaluated for processing quality. There were no consistent seasonal differences in pH and titratable acidity, but Hunter color readings and soluble solids (^{O}Brix) were consistently higher for fruits harvested during the drier, cooler months (September and November). Although significant differences between lines were not consistent over all harvests, line CL 9-0-0-1-3 generally had higher Hunter color readings and soluble solids in all harvests than the other lines.

Chinese cabbage quality assessment

Thirteen AVRDC hybrids and four local heat tolerant cultivars (Summer Light No. 2, Summer Light No. 4, Win Wu and Feng Luh) were evaluated for dry matter, pH, soluble solids, titratable acidity, crude fiber, pectic substances, sugar and vitamin C. Based on these parameters, the quality of AVRDC hybrids was equal to or better than that of the local cultivars. Most of the hybrids had higher dry matter, soluble solids and pectic substances, and lower crude fiber than Feng Luh, a popular cultivar in Taiwan.



Assessing the color characteristics of AVRDC processing tomatoes.

Nutrition Garden Program

AVRDC home and school gardens were tested in 1981 and showed how low-input gardens could be used by nutrition intervention programs in Asia.

Home gardens for the lowland tropics

Home gardens comprising an intercrop of nutritious and culturally acceptable vegetables were designed for Indonesia, the Philippines and Thailand, and evaluated from June to September 1981. The gardens were designed to provide a significant percentage of a five-member family's recommended daily requirements for calcium, iron, vitamins A and C, as well as measurable amounts of protein. A 'Vitamin A garden' was also evaluated to determine how much of this nutrient could be produced in a small plot.

Nutrient production of four home gardens in the AVRDC Garden Program

Garden	% FAO RDA (for a family of five)[a]				
	Protein	calcium	iron	Vit. A	Vit. C
Thailand	19	67	75	104	633
Indonesia	23	51	74	126	254
Philippines	6	12	26	22	91
Vitamin A	15	56	83	124	492
Objectives		40	40	80	100

[a]UN Food and Agriculture Organization recommended dietary allowance

Each of the four gardens was planted with low input agricultural practices in a 4 x 4m plot divided into three 4 x 1.5m raised beds. The Indonesia garden consisted of water spinach, yardlong beans growing with cassava, amaranth with red onions, and winged beans intercropped with sweet potato. The Philippine garden consisted of hyacinth bean and malunggay, pai tsai (non-heading Chinese cabbage) intercropped with eggplant, pai tsai intercropped with snap bean, Chinese leek and eggplant. The Thailand garden consisted of pai tsai intercropped with Chinese mustard, hyacinth bean, ipil-ipil trees, and yardlong beans intercropped with sweet potato. The vitamin A garden consisted of pai tsai with red onion, mango and papaya trees,

high β-carotene tomato intercropped with red onion, and Chinese mustard intercropped with chili pepper.

All of the gardens exceeded the nutrient objectives with the exception of the garden designed for the Philippines. The Philippine garden failed to provide expected percentages of calcium, iron and vitamin A, partly because of heavy rains and aphid attacks, and partly because of the inclusion of eggplant, a culturally acceptable but somewhat nutritionally deficient vegetable. These gardens will be modified to fit the seasons over the course of a full agricultural cycle.

School gardens for the lowland tropics

School gardens were designed with the objectives of providing 55g cooked vegetables to 100 children five days per week for at least 60 days during a school-term growing and harvesting period. The garden consisted of wide-leaf kangkong (water spinach), amaranth, Chinese radish, Chinese mustard, pai tsai intercropped with lima bean, sweet potato intercropped with winged bean, leaf lettuce, and yardlong bean intercropped with sweet potato. Crop selection was based on nutrient content and cultural acceptability. Plot size measured 10 x 18m comprising twelve 10 x 1.5m raised beds. Low input agricultural practices were followed.

The school garden produced enough vegetables in an average 96-day growing period to provide each of 100 children with 78.7g vegetables per day. This 78.7g portion would contribute a significant percentage of a 10-12-year-old child's daily recommended dietary allowance for protein (4.4%), calcium (17.6%), iron (70%), vitamin A (34%) and vitamin C (191%).

Market gardens for the lowland tropics

Market gardens were evaluated for their income-generation potential through the cul-

Recording the yield of a home garden.

tivation of crops in high demand at local markets. Crops were selected on the basis of surveys of major local markets in Taiwan, and included Chinese cabbage, tomato, Chinese mustard, common cabbage, Chinese radish, eggplant, cucumber and Chinese leek. Plot size was 10 x 18m comprising twelve 10 x 1.5m raised beds. Standard AVRDC production practices were followed, and the harvested produce was sold to merchants at local markets.

The market garden produced 386 kg marketable vegetables in a 72-day growing period. Assuming that household members furnished the labor, the total cost for seeds, pesticides and fertilizer was approximately US$6. Net return to the family was approximately US$126. Projected over a full year agricultural cycle, the annual net income to the family would have been US$630.

Soil Science

Compost and tomato yields

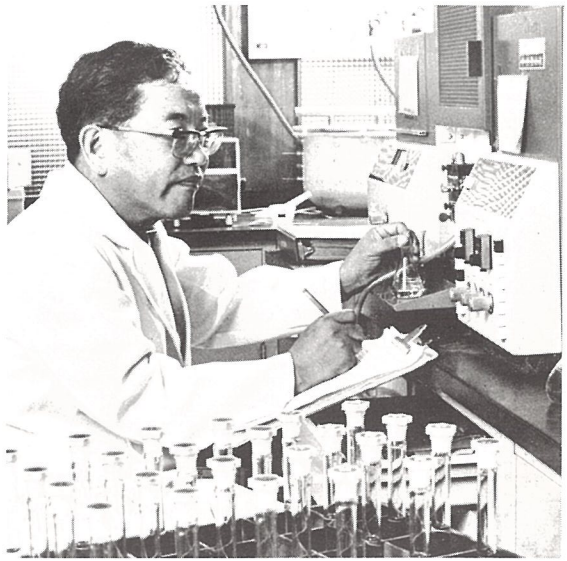
A field experiment was conducted with tomato to assess the effects of compost, fertilizer type and rate on tomato yields in a rice-rice-tomato field. The experiment followed an $L_{27}(3^{13})$ orthogonal factorial design with three levels of compost (0, 40 or 80 t/ha) and fertilizers (100, 200 or 300 kg/ha), and three types of fertilizers (ammonium sulfate, coated fertilizer (17-0-17) 100-day type, or coated fertilizer (43-0-0) 100-day type). There were no significant differences in marketable yield resulting from fertilizer type or rate. Rice straw compost at 80 t/ha, however, brought about significant increases in marketable yield weight, fruit number per plant, total fruit number and fruit acidity.

Field soil characteristics after rice and vegetables

A survey of soil samples taken after a rice harvest and after a Chinese cabbage or

Extracting soil samples to assess the fertilizer residues left behind by an earlier crop of Chinese cabbage.

tomato harvest indicated that harvested vegetable fields still contained significant fertilizer materials, and that these affect the chemical and physical soil characteristics for succeeding experiments. A total of 152 soil samples were collected from fields after a first or second paddy rice crop, and 68 more samples were collected from fields after a tomato or Chinese cabbage harvest. About 97% of the rice soil samples and 77% of the vegetable soil samples had electrical conductivity (EC) values of 0.43 mmho/cm or less. The remaining 23% of the vegetable soil samples had higher EC values up to 1.6 mmho/cm. The majority of the vegetable soils measured acidic, whereas the majority of the rice soils measured neutral or slightly alkaline. The vegetable soils generally had higher P_2O_5 and K_2O contents but lower Ca and Mg contents than the rice soil samples. Soil uniformity for vegetable experiments can be promoted by including paddy rice culture as a land preparation practice. Several close correlations were obtained between various soil characteristics within both vegetable and rice soil samples which are expected to be useful in making soil diagnoses and fertilizer recommendations.



An AVRDC soil scientist analyzes one of the more than 30,000 soil and plant samples tested at AVRDC in 1981.

Improving nitrogen top-dressing techniques for Chinese cabbage

In evaluations of different application techniques for the first nitrogen (30 kg ^{15}N/ha) top-dressing on Chinese cabbage, double band applications resulted in the highest absorption rate of 70%, followed by single band applications with a 58% absorption rate. Other treatments included nitrogen applied in one spot 1) per four hills, 2) between hills, 3) per hill or 4) broadcast over the bed. Nitrogen applied according to the standard AVRDC fertilization schedule for Chinese cabbage (80 kg/ha basal dressing and three 30 kg/ha top-dressings in one spot per hill at 7, 14 and 28 days after transplanting) showed a 35% absorption rate.

Nitrogen application timing and nitrogen fixation in soybean

High levels of inorganic nitrogen at the initial growth stages of a leguminous crop are reported to disturb nodule formation and the resulting nitrogen fixation by nodule bacteria. An experiment was thus conducted to determine whether basal nitrogen applications adversely affected nitrogen fixation in soybean. Nodulating and non-nodulating soybean isolines grown in pots were treated with 300 mg N/pot basally versus ten days after germination, and again at flower initiation and pod filling stages. Nodule nitrogen fixation contributed approximately 58% to the total nitrogen absorption of the plants in both treatments.

Solution culture for determination of critical nutrient concentrations

Solution culture was used in a preliminary study to determine the critical concentration of certain nutrients for mungbean, tomato and Chinese cabbage. Plants were sown in plastic pots filled with quartz sand, and the pots were then suspended through a styrofoam plate into a flat filled with the culture solution. Critical concentrations at which plants began to show adverse reactions were determined for phosphorus, potassium and magnesium.

Critical nutrient determinations for mungbean, tomato and Chinese cabbage grown in solution culture

Crop	Nutrient (ppm)		
	Phosphorus	Potassium	Magnesium
Mungbean	0.5 - 0.1	2 - 4	0.8 - 1.6
Tomato	2.0 - 4.0	2 - 4	0.8 - 1.6
Chinese cabbage	2.0 - 4.0	8 - 16	1.6

Mg def.

A magnesium deficient Chinese cabbage leaf from a plant grown in solution culture (above) compares poorly with a leaf from the healthy check (below).

Check

Crop Management

Leaf-tying and shading of summer Chinese cabbage

Experiments using AVRDC's heat tolerant Chinese cabbage hybrid 62 and heat sensitive local cultivar Bing Luh were conducted to determine if shading and leaf-tying could increase the yield of Chinese cabbage grown in summer. Treatments included leaf-tying, black plastic cover, nylon net cover and an untreated check arranged in a randomized complete block design with three replications. In the first treatment, all except the outermost Chinese cabbage leaves were loosely tied at the apex 30 days after transplanting to provide shade for the developing inner leaves. In the second treatment, the leaves were loosely grouped and wrapped with black plastic. In the third treatment, 1 mm mesh nylon netting covered the entire bed 40 cm above the soil surface. None of the treatments significantly increased the marketable yield or head quality of heat tolerant hybrid 62, but leaf-tying significantly increased the marketable yield and head weight of heat sensitive Bing Luh.

Leaf-tying heat susceptible Chinese cabbage can provide farmers with viable yields during the summer season.

Effect of shading and leaf-tying on yield characteristics of heat sensitive Chinese cabbage cultivar Bing Luh[a]

Treatment	Yield (t/ha)	Head weight (kg/head)
Leaf-tying	25.2	0.89
Black plastic	13.4	0.69
Nylon net	15.5	0.65
Check	12.7	0.52

[a]Transplanted

Raised bed heights are a potential solution to the problem of flooding during the summer season. AVRDC management specialists have found that 30 cm high beds can minimize flood damage as evidenced by the vigorous Chinese cabbage plants on the right.

Effect of bed height and width on summer Chinese cabbage

Bed heights of 30 cm can minimize flood damage to Chinese cabbage in the summer monsoon season, resulting in economic yields. In an experiment conducted over several summer seasons, Chinese cabbage was planted in a split-plot experimental design. The main plots comprised three bed widths (100, 150 and 200 cm), with subplots comprising three bed heights (15, 30 and 45 cm). Total precipitation during the growing period (July 22 to September 7, 1981) was 855 mm. Marketable yields from the 30 cm and 45 cm high beds were 12.1 t/ha and 14.3 t/ha respectively, compared with 6.3 t/ha from the 15 cm beds. Bed width had no effect on yields or survival rates. The results show that under high rainfall conditions, a 30 cm bed height was sufficient insurance to permit economic yields. Under conditions of medium to low rainfall, a 15 cm bed height or even planting on the flat produced economic Chinese cabbage yields.

Effect of bed height and width on summer tomato

Under heavy rainfall conditions, bed heights of 30 cm and 45 cm resulted in marketable tomato yields of 8.2 t/ha and 9.1 t/ha respectively, compared with 1.1 t/ha from a 15 cm bed. The experiment, conducted over several summer seasons, was designed to determine the optimum bed height and width for tomato grown during the summer monsoon season. The split-plot experimental design comprised two bed widths (100 and 200 cm), with subplots comprising three bed heights (15,30 and 45 cm). Total precipitation was 1220 mm during the growing period. The plant survival rate was 39% on the 15 cm bed. Under heavy rainfall conditions, a 30 cm bed height is sufficient to produce economic tomato yields.

Herbicide evaluations for transplanted tomato

In a spring season evaluation of three herbicides for weed control in transplanted tomato, alachlor was most effective for grass control, whereas oxyfluorfen was most effective for broadleaf weeds. Metribuzin controlled both weed types. Treatments consisted of alachlor at 1.00, 2.00 and 4.00 kg ai/ha; metribuzin at 0.25, 0.50, 0.75 and 1.00 kg ai/ha; oxyfluorfen at 0.25, 0.50, 0.75, 1.00, 1.25 and 1.50 kg ai/ha; manual weedings between four and six weeks after transplanting; a weedy check and a weed-free check. Phytotoxicity, as measured by tomato plant height, was most severe with oxyfluorfen, moderate with alachlor and absent with metribuzin. Only metribuzin at 1.00 kg ai/ha and weeding between four and six weeks after transplanting resulted in yields equivalent to that of the weed-free check.

Herbicide evaluations for soybean

Herbicide evaluations were conducted for soybean during spring, summer and fall to identify effective preemergence herbicides. In the spring screening, treatments consisted of oxyfluorfen, metribuzin, alachlor, chloramben, manual weedings between 45 and 60 days after planting (DAP), and weedy and weed-free checks. Oxyfluorfen at more than 0.25 kg ai/ha and metribuzin at more than 0.50 kg ai/ha were significantly phytotoxic, whereas chloramben and alachlor were selective. Only alachlor at 3.00 kg ai/ha and the 45-60 DAP weeding resulted in weed fresh-weights significantly lower than the weedy check. All alachlor treatments, oxyfluorfen at 0.25 kg ai/ha and the 45-60 DAP weeding resulted in soybean yields as high as that of the weed-free check.

In the summer screening, oxyfluorfen was applied alone and in combination with alachlor. Dual 500 EC, Galex 500 EC and manual weedings between 45 and 60 DAP were also evaluated. All Dual 500 EC and Galex 500 EC

Applying herbicides in an AVRDC experimental plot.

treatments resulted in seed yields as high as that of the weed-free check, whereas yields from the oxyfluorfen, oxyfluorfen + alachlor, and 45-60 DAP weeding treatments were reduced significantly.

In the fall screening, Dual 500 EC and Galex 500 EC were evaluated to determine economic dosages for the fall soybean cropping season. Dual 500 EC at 1.0 kg ai/ha and Galex 500 EC at 1.5 kg ai/ha proved most economically effective.

Plant spacing studies for soybean

Studies were continued in 1981 using soybean line AGS 17 to determine the optimum soybean spacing for a population density of 400,000 plants/ha (AVRDC Progress Report 1980). Two between-row spacings (25 and 50 cm) and three within-row spacings (10, 20 and 30 cm) were combined factorially for a total of six treatments conducted in spring and fall. Within-row spacing had no effect on soybean yields except in the fall trial in which yields from the 10 and 20 cm spacings were significantly greater than that from the 30 cm spacing. Between-row spacings of 25 cm resulted in significantly higher yields than 50 cm spacings in both trials (3.28 t/ha vs 3.01 t/ha in spring, and 2.17 t/ha vs 2.04 t/ha in fall). Combined with data from trials in 1980, results suggest that for semi-determinant, broad-leaflet types similar to AGS 17, optimal spacing should be 25 cm between rows, and from 10 to 20 cm within rows.

Plant spacing studies for mungbean

Studies were continued in 1981 on mungbean line VC 1628 A to determine the optimum spacing for a population density of 400,000 plants/ha (AVRDC Progress Report 1980). Two between-row spacings (25 and 50 cm) and three within-row spacings (10, 20 and 30 cm) were combined factorially for a total of six treatments conducted in spring and fall. Within-row spacings of 10 cm resulted in significantly higher yields in the spring trial,

Trials conducted with semi-determinant, broad-leaflet soybean selections suggest that optimal yields can be obtained when seeds are planted in rows 25 cm apart and at distances of 10 to 20 cm within the rows.

whereas 20 cm within-row spacings resulted in the highest yields in the fall. Yields from both trials were significantly higher with between-row spacings of 25 cm. Spacing had no effect on mungbean yield components, but significantly affected plant stand. Combined with the data from trials in 1980, these results suggest that optimal spacing for relatively short plant types is 25 cm between rows, and from 10 to 20 cm within rows.

Herbicide screening for mungbean

Dual 500 EC, Galex 500 EC, butralin, alachlor, oxyfluorfen and Modown were evaluated as preemergence herbicides for mungbean during the summer season. Treatments consisted of herbicide applications, manual weedings between 30 and 60 days after planting (DAP), and weedy and weed-free checks. Although Dual and Galex were the most effective of the herbicides tested, neither sufficiently controlled weeds to prevent yield loss. Only the 30-60 DAP weedings resulted in yields as high as that of the weed-free check.

Nitrogen application timing for maximum sweet potato yield

A field trial was conducted to determine the most efficient timing sequence for nitrogen fertilizer applications on sweet potato. All treatments, except the check, received a total of 90 kg N/ha in one, two or three applications at various combinations of 0, 20, 30, 40, 50 and 80 days after planting (DAP). Sixty kg P_2O_5/ha and 180 kg K_2O/ha were applied basally to all treatments.

Although all treatments gave higher yields than the check (17.94 t/ha), significant yield increases were obtained only from applications at 20 DAP (24.22 t/ha); 30 DAP (23.5 t/ha); and 20 and 80 DAP (22.44 t/ha). Yield differences were due mainly to differences in root size ($r = 0.697^*$) and root number ($r = 0.900^{**}$).

Fertilizer utilization trials have indicated that split applications of N can help to maximize a farmer's sweet potato yields.

Economics and Social Anthropology

Processing vegetable soybeans for export to Japan.

Economic survey of the vegetable soybean industry in Taiwan

Vegetable soybeans are grown for fresh consumption. At the present time, 90% of the vegetable soybean in Taiwan is frozen for export to Japan, representing a significant income to local farmers.

To examine the nature of the vegetable soybean industry in Taiwan, a survey was conducted with 42 farmers, three middlemen who contract production, two frozen food processors and a representative of a Japanese trading firm. The survey revealed that excessive rain at germination and at pod formation is the farmers' most serious constraint. Average production cost, net return to the land and whole plant yield in the 1980 winter cropping season were US$827/ha, US$ 497/ha and 21 t/ha, respectively. Harvesting begins at midnight and is carried out by laborers hired by middlemen. Selection of pods suitable for processing is done in the early morning. Middlemen transport the selected pods to food processors for quick freezing. The finished product is exported primarily through large Japanese trading firms, but Japanese food manufacturers and retailers are beginning to buy directly. Vegetable soybean exports were worth US$ 21 million in 1981.

To remain competitive, the vegetable soybean industry in Taiwan must reduce costs and have access to cultivars with larger seeds, a greater ratio of three-seeded pods, year-round adaptability and longer fresh-storage life. Steps should also be taken to reduce the financial risks of processors.

Response of soybeans to management inputs

Various soybean management inputs were assessed from an economic standpoint to identify possible improvements in input use for

soybean management studies. Based on input costs in Taiwan, the evaluation was conducted with three soybean cultivars (AGS 62, AGS 124 and AGS 144) during the spring cropping season, and comprised four treatments:

T1: land preparation, furrowing and sowing only;
T2: T1 + lasso and paraquat sprayings immediately after sowing;
T3: T1 + manual weeding at 60 DAP; and
T4: Standard AVRDC cultural practices (AVRDC Guide no. 79-112).

A simple linear regression analysis of the yield by treatment cost and yield was done according to the formula $Y = MX + B$, where Y = soybean yield (kg/ha) and X = treatment cost (NT$/ha).

Yield and treatment costs were significantly correlated in all three cultivars (AGS 62, $r = 0.983^{**}$; AGS 124, $r = 0.984^{**}$; AGS 144, $r = 0.948^{*}$). The marginal costs per kilogram yield increase for treatments T3 and T4 were higher than the ROC government's guaranteed price of NT$17/kg. It is recommended that T3 be dropped from future management evaluations, and that the individual components of T4 be evaluated to identify the optimum soybean cultural practices under AVRDC conditions.

Vegetable farming cooperatives in Taiwan

In July 1981, the AVRDC Social Anthropology Unit began a study of group vegetable farming in Taiwan and the means whereby farmers cooperate to solve problems. Preliminary findings indicate that vegetable marketing is well-suited to cooperative management, but production is not easily organized on a cooperative basis. Production cooperatives are hindered by high risks, complex cultural practices, high labor inputs and varied cropping patterns, as well as institutional factors including land supply, access to credit and untrained leadership.

Surveying a farm family in rural Taiwan.

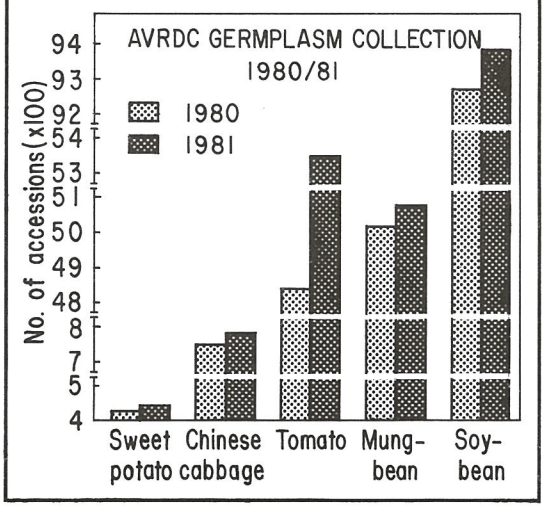
Genetic Resources and Phytosanitation

AVRDC's Seed Laboratory is responsible for the testing and preservation of more than 20,000 accessions. These genetic resources provide the diversity required to breed new crop types and have played a major role in the development of the Center's agronomically superior selections.

Seed Laboratory activities are not restricted to the confines of AVRDC, however. Center policy emphasizes the liberal dissemination of germplasm samples to organizations involved in crop improvement and agricultural development throughout the world. In 1981, more than 12,000 seed packets were distributed free of charge to collaborators in 77 countries.

To ensure that these planting materials are disease and insect free, each germplasm sample that emanates from the Center is treated according to exacting standards. This may vary from chemical and heat treatments for tomato seeds, to the tissue culturing of vegetatively propagated crops such as sweet potato. In each case, collaborators can be sure that AVRDC germplasm meets the highest international phytosanitary requirements.

The International Board for Plant Genetic Resources (IBPGR) awarded a grant to AVRDC in 1981 to support the multiplication of its Chinese cabbage germplasm collection. Funds are also being provided for the long-term storage of the collection at Britain's National Vegetable Research Station, Wellesbourne. Pictured above is Seed Lab Chief Leonard Ho rating various accessions.



TRAINING

Training is an integral part of AVRDC's mandate aimed at addressing the needs of national programs for qualified and motivated research personnel. Since the program's modest beginnings in 1974, more than 350 persons from 29 countries have attended Center training programs - many of whom have returned home to assume positions of leadership in national research and development programs.

In 1981 alone, 66 persons completed training courses at AVRDC, including the Center's first participants from Tonga and El Salvador. This number, which is a record for AVRDC, is also an indication of the Center's commitment to training and the international recognition accorded to its training programs.

Essentially, AVRDC training can be divided into three components that correspond to the experience and capabilities of the training scholars involved. Included are programs for persons pursuing academic degrees, researchers with recently conferred MA's and PhD's as well as technicians working in national or commercial research programs. Each of these scholars may pursue one of several disciplines in either the vegetable or legume crop training programs. In addition, AVRDC also provides special production training courses for agricultural development officers and summer courses for agricultural undergraduates. All of these programs, however, share the common goal of enhancing the knowledge, skills and capabilities of the

Training scholars work closely with AVRDC scientists, both in the classroom and in the field.

Scholars and staff alike utilize AVRDC's research library. The present collection of materials includes more than 11,000 publications and audio-visuals.

Since 1974, AVRDC and the Korean Office of Rural Development (ORD) have co-sponsored a soybean research and training program that plays an important role in that country's soybean improvement efforts. Each year an ORD researcher is posted to AVRDC during the winter season and carries out a generation-advance of selected ORD soybean cultivars. At the same time, he participates in AVRDC's training program in order to upgrade his soybean research and production skills. In this way, the ORD gains an extra season for its soybean improvement program, while providing advanced training for one of its senior personnel. Pictured above is Kim Seok-Dong, the latest ORD researcher to participate in the program.

participants so that they in turn can contribute to research and production efforts in their own countries.

Despite the flexibility of these programs, AVRDC has long recognized the need for a training program that can specifically address the personnel requirements of national research programs in Southeast Asia. For this reason the Center began the process in 1981 of establishing its first off-site training program at the Kampaensaen Campus of Kasetsart University in Thailand. While the program will closely reflect AVRDC training programs in Taiwan, it will also have a number of unique features. For example, the program calls for a course of study especially addressed to the agro-environmental factors faced by national research programs in the region. In addition, it is the first AVRDC training program to be formally linked to one of the Center's bilateral projects. In combination, these factors will provide training scholars with a unique opportunity to observe and work with an international research and field testing program, as well as to study and develop their own capabilities in accord with the environments in which they will be working (also see Thailand Bilateral Project).

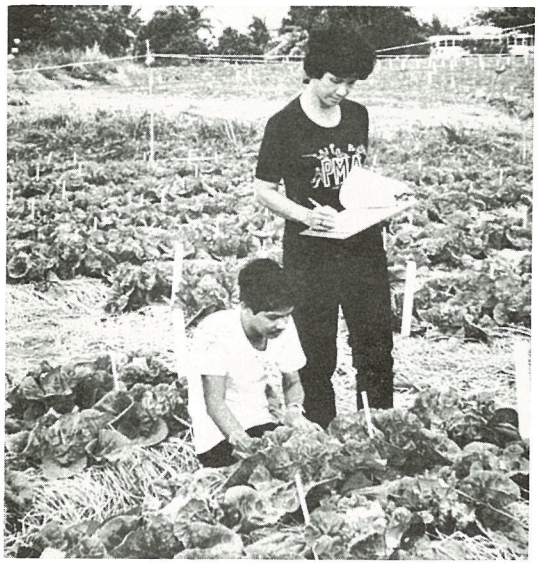
Bilateral, Development and Collaborative Projects

AVRDC's bilateral, development and collaborative projects are the Center's primary means of testing and ultimately transferring improved selections and cultural practices to farmers. AVRDC does not work with farmers directly, however. Rather, it utilizes these programs to establish collaborative research projects with organizations responsible for agricultural development at the national and regional level. In this way, technologies developed at AVRDC can be tested and modified to meet farmer requirements in a multiple of locales.

At the present time, AVRDC technology is being tested in more than 75 countries. As the need for location-specific research grows, however, AVRDC is taking steps to expand the scope of its cooperative projects and accelerate the adoption and utilization of its research product. This is true not only of its formal bilateral projects in Asia, but of its collaborative programs with research and development agencies worldwide.

The Korean Bilateral Project

The Korean Bilateral Project commenced operations in 1976 and conducts an intensive program of research on Chinese cabbage and tomato. While its crop mandate is limited, the project played a major role in the



Rating Chinese cabbage cultivars at the Philippine Bilateral Project in Los Baños.

official release of two Chinese cabbage cultivars in Korea that were developed from AVRDC parental stocks. This achievement was largely the result of a research program that closely corresponds to the crop improvement programs conducted at AVRDC. In 1981, for example, project scientists conducted a series of studies aimed at assessing the combining ability and cytoplasmic male sterility of AVRDC Chinese cabbage, as well as the heat and disease tolerance of the Center's tropical tomatoes. Based on this type of research, additional cultivar releases are expected in the near future.

The Philippine Bilateral Project

The Philippine Bilateral Project was inaugurated in 1975 to test and adapt AVRDC cultivars to Philippine environmental conditions. The oldest of AVRDC's bilateral projects, the program was originally funded by the Asian Development Bank, and is now sponsored by the Philippine government under the auspicies of the Bureau of Plant Industry.

While specific responsibilities vary from year to year, the program generally concentrates on the screening of crop selections supplied by AVRDC. In 1981, for example, hundreds of lines were tested by project scientists, and 18 selected for regional trials in 1982. These included stable, high-yielding varieties of tomato, Chinese cabbage, sweet potato, mungbean and soybean. If successful in the 1982 trials, several of these selections will be recommended to the Philippine Seed Board for release to farmers.

The Thailand Bilateral Project

The Thailand Bilateral Project is AVRDC's first formal research and training program

on the Southeast Asian mainland. Funded by the Asian Development Bank, the Kingdom of Thailand and AVRDC, the project commenced operations in the latter part of 1981 at Kasetsart University. Its objective is to test AVRDC technology under Thai environmental conditions, as well as provide research and training support to neighboring countries in the region. Activities to date have been limited to variety testing and establishing a base of operations. Full-scale research is expected to commence in 1982.

The Taiwan Development Program

AVRDC's Taiwan Development Program was established in 1979 and operates on a basis similar to the Center's bilateral projects. Working with local research and extension organizations, the program has provided Center scientists with a large body of data on the performance and potential of AVRDC crops, and has been instrumental in the testing and release of AVRDC mungbean, soybean, tomato and Chinese cabbage selections.

In 1981, program activities included a series of trials conducted in collaboration with District Agricultural Improvement Stations at 6 locations. From these trials, five AVRDC mungbean selections were noted for outyielding local cultivars by as much as 80 percent. AVRDC tomato, Chinese cabbage and soybean selections also outyielded local checks, a number of which are now scheduled for release in 1982.

An AVRDC Development Officer (left) with a soybean cooperator in Taiwan.

Collaborative Projects with National Programs

In addition to its bilateral and development projects, AVRDC also works on a collaborative basis with scientists in national

Dr. J. L. Tickoo of the Indian Agricultural Research Institute selecting AVRDC mungbean lines.

research programs throughout the world. The following are examples of the reports received from collaborators in 1981.

Australia

Mungbean VC 1560 D was used by the Institute of Biological Resources as a source of disease resistance in a backcross program. Selection VC 1974 A also showed considerable disease resistance and is slated for further testing in 1982.

Brunei

Eight AVRDC tomato breeding lines were screened by the Department of Agriculture and demonstrated significantly higher rates of bacterial wilt resistance than check lines from Hawaii.

Guatemala

AGS 62, a narrow-leaflet, early maturing soybean yielded 1.9 t/ha compared to the local check's 1.3 t/ha in trials conducted by the Institute of Agricultural Science and Technology. This line will likely be released to farmers in 1982 or 1983.

India

Four AVRDC selections outyielded 48 elite Indian mungbean lines in trials conducted at AVRDC by a visiting scientist of the Indian Agricultural Research Institute (IARI). These lines are now being used in IARI's mungbean improvement program.

Indonesia

Sixty-two mungbean breeding lines and accessions were evaluated by the Central Research Institute for Agriculture with four lines rating highly resistant to *Cercospora* leafspot and powdery mildew. Fourteen AVRDC Chinese cabbage lines were also cleared for testing and several will likely be released in 1983.

Malaysia

AVRDC mungbean lines VC 1647 B and VC 1482 C significantly outyielded the local check cultivar in trials conducted by the Agricultural Research Center in Senmongok. Line VC 1482 C also demonstrated substantial resistance to *Cercospora* leafspot.

Pakistan

Soybean GC 40359-1-51-11 yielded 1.5 t/ha compared to 1.2 t/ha for Bossier and 0.8 t/ha for Bragg in trials conducted by the Agriculture Research Institute.

Saudi Arabia

Three open pollinated and two F_1 hybrid Chinese cabbage lines provided economically viable yields ranging from 5 to 10 t/ha in trials conducted by the ROC Agricultural Technical Mission in Hofuf. Maximum daily temperatures during the trial period ranged from 45°C to 50°C.

Senegal

Ten AVRDC tomato lines were tested by the Center for the Development of Horticulture. CL 143-0-10-3-UG proved to be well adapted to local conditions, but suffered damage from rootknot nematode. AVRDC breeders are now incorporating nematode resistance into this promising line.

Seychelles

Six AVRDC tomato lines were multipled by government extension workers for distribution to farmers in 1982.

Sri Lanka

AVRDC tomato selection CL 143-0-10-3 provided marketable yields of 43 t/ha in government trials, compared to 31 t/ha for check L 2. Reports also indicate that an AVRDC

Malaysian Ministry of Agriculture officials examining AVRDC high yielding soybean selections.

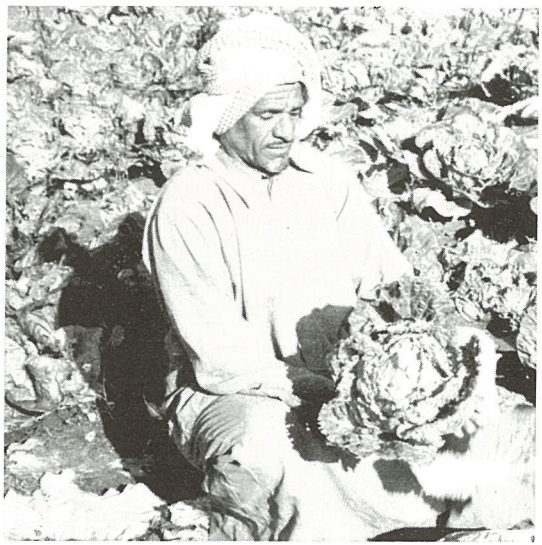
soybean selection will be released in the near future.

Thailand

Eight AVRDC mungbean selections tested at Kasetsart and Chiang Mai Universities rated highly resistant to *Cercospora* leafspot. Six of these lines also outyielded the local check in trials conducted at seven locations over three seasons.

U.S.A.

Two F_1 Chinese cabbage hybrids yielded more than 20 t/ha compared to 0 t/ha for a check cultivar at the Organic Farm Research Center in Pennsylvania. Five other AVRDC selections were also chosen for testing in 1982.



A Saudi Arabian farmer with his crop of AVRDC heat tolerant Chinese cabbage.

CGIAR Collaborative Projects

AVRDC also works extensively with the Centers of the Consultative Group on International Agricultural Research (CGIAR) on projects of mutual interest. As AVRDC selections have gained wider acceptance, these projects are gradually expanding to play a more active role in CGIAR research efforts, particularly those involving cropping systems.

The International Rice Research Institute (IRRI)

A formal agreement was signed in 1981 that has established a program of collaborative research between AVRDC's crop improvement programs and farming systems research presently underway at IRRI. The program will evaluate the effectiveness of AVRDC crop selections under a variety of conditions, and is aimed at incorporating vegetables and legumes into rice-based cropping systems.

The International Institute of Tropical Agriculture (IITA)

A similar agreement was signed with IITA in 1981 that provides for the testing of AVRDC crops grown under African cropping systems. The program is expected to lay the ground work for an expansion of the Center's activities with national programs on that continent.

International Center for Tropical Agriculture (CIAT)

AVRDC and CIAT have collaborated on a number of projects over the years. The most recent example concerns the testing of CIAT snapbean selections for beanfly tolerance. On the basis of this research, two resistant lines have been identified and are now undergoing further study.

International Service for National Agricultural Research (ISNAR)

Details were completed in 1981 for a survey that will assist ISNAR in preparing an agricultural research plan for Papua New Guinea. Under a joint agreement, AVRDC will supply a scientist to ISNAR in 1982 to evaluate the requirements for establishing a vegetable crop research program in that country.

The International Board for Plant Genetic Resources (IBPGR)

(see Genetic Resources and Phytosanitation)

The distribution of seed samples for international testing is an integral part of AVRDC's program of collaborative research. In 1981, more than 12,000 samples were distributed to collaborators in 77 countries and territories around the world.

Collaborating Organizations

Argentina
Crawford, Keen & Cia
Instituto Nacional de Technologia Agropecuaria
Semillero Elceibo

Australia
Commonwealth Scientific and Industrial Research Organization
Institute of Biological Resources

Bangladesh
Bangladesh Agricultural Research Council

Bolivia
Coluite de Obras Publicas
ENC Oleaginosas
ROC Technical Mission

Brazil
EMBRAPA
CU/NCSU Project
Universidad Federal de Vicosa

Brunei
Department of Agriculture

Canada
Ministry of Agriculture and Food

Colombia
International Center for Tropical Agriculture

Costa Rica
Universidad de Costa Rica

Germany
Biologische Bundesanstalt
Deutsche Gesellschaft fuer Technische Zusammenarbeit

Guatemala
Plenty Agricultural Project

Haiti
Compagnes de Jesus

Honduras
CEDEN
Escuela Agricola Panamericana
ROC Technical Mission
UNHA

India
Department of Agriculture, Tamil Nadu
G. B. Pant University of Agriculture and Technology
Indian Agricultural Research Institute
Indian Council of Agricultural Research
Maharashtre Association for the Cultivation of Science Research Institute
Punjab Agricultural University
Regional Pulses Research Center, Tamil Nadu
Tamil Nadu Agricultural University

Indonesia
Central Research Institute for Agriculture
Institute Pertanian Bogor
ROC Technical Mission

Italy
International Board for Plant Genetic Resources
United Nation Food and Agriculture Organization

Japan
Japanese Interchange Cooperation Agency
Kyushu University
Ministry of Agriculture, Forestry and Fisheries
University of Osaka
Vegetable and Ornamental Crops Research Station

Jordan
Ministry of Agriculture

Korea
Crop Experimental Station, Office of Rural Development
Horticultural Experimental Station, Office of Rural Development

Malaysia
Agricultural Research Center, Senmongok
Department of Agriculture, Sarawak
Joint Malaysian Soybean Breeding Project
MARDI
Rubber Research Institute
Rural Development Corporation Sabah
University of Kebangsan
University of Malaysia
University Pertanian

Netherlands
International Service for National Agricultural Research
Glasshouse Crops Research and Experimental Station
Wageningen University of Agriculture

Nigeria
International Institute of Tropical Agriculture

Panama
Instituto de Investigacion Agropeuaria de Panama

Pakistan
Agricultural Research Institute

Papua New Guinea
Department of Primary Industries

Peru
Amazon Jungle Research Project
Instituto Nacional de Investigacion Agraria
Universidad Nacional Agraria

Philippines
Asian Development Bank
Bureau of Plant Industry
Central Philippines University
International Rice Research Institute
Mindanao State University
National Food and Agriculture Council
Philippines Council for Agricultural and Crop Resources Research
Philippines Root Crop Research and Training Center
South East Asian Center for Graduate Study
University of the Philippines, Los Baños

Saudi Arabia
Ministry of Agriculture and Water
ROC Technical Mission

Senegal
Center for the Development of Horticulture

Sri Lanka
Agricultural Development Authority
University of Peradeniya

Thailand
Asian Institute of Technology
Chiang Mai University
Kasetsart University
Khon Kuen University
Ministry of Agriculture
Sub-committee for Vegetable Research and Development Collaboration

Taiwan
Academia Sinica
Agricultural Association of China
Agricultural Engineering Research Institute
Asian and Pacific Food and Fertilizer Technology Center
Chiayi Agricultural Experimental Station
Chinese Culture University
Chu-Pei Farmers' Association
Council for Agricultural Planning and Development
Dah-cheng Farmers' Association
Ehr-lin Farmers' Association
Ehr-ren Farmers' Association
Fengshan Tropical Horticultural Experimental Station
Food Industry Research and Development Institute
Hsih-fu Cooperative Farm
Hsinchu District Agriculture Improvement Station
Hsin-kang Cooperative Farm
Hsin-kang Farmers' Association
Hualien District Agriculture Improvement Station
I-tsu Cooperative Farm
Kaohsiung District Agriculture Improvement Station
Lu-chu Cooperative Farm
Lun-yang Cooperative Farm
Lu-tsau Cooperative Farm
Mountain Agricultural Resources Development Center
Nan-ho Cooperative Farm
National Cheng-kung University
National Chung-hsing University
National Taiwan University
Provincial Department of Education
Ren-bay Farmers' Association
Shanhua Farmers' Association
Shih-lou Farmers' Association
Shih-tzou Farmers' Association
Shui-lin Farmers' Association
Taichung District Agriculture Improvement Station
Tainan District Agriculture Improvement Station
Tai-pau Farmers' Association
Taipei District Agriculture Improvement Station
Taitung District Agriculture Improvement Station
Taiwan Agricultural Research Institute
Taiwan Seed Improvement Service
Taiwan Sugar Research Institute
Tung-shih Farmers' Association
World Vision

Trinidad
Carribbean Agricultural Research and Development Institute

United Kingdom
National Vegetable Research Station, Wellesbourne
University of Reading

United States
Cornell University
East-West Center
International Soybean Program
International Agricultural Development Service
International Volunteer Service
Iowa State University
IRI Research Institute
Land O'Lakes, Inc.
Louisiana State University
Organic Farm Research Center
Texas A & M University
United States Department of Agriculture
University of California (Berkeley)
University of California (Davis)
University of Georgia
University of Hawaii
University of Illinois
University of Maryland
University of Missouri
University of New Hampshire
University of Puerto Rico
University of Rhode Island
U. S. Agency for International Development
Virginia Polytechnic Institute
Volunteers in Asia

Germplasm Recipients

Organizations in the following countries and territories received AVRDC germplasm in 1980-81 for testing and incorporation with local cultivars:

Anguilla Islands
Antigua
Argentina
Australia
Bahrain
Bangladesh
Barbados
Belgium
Botswana
Burma
Canada
Colombia
Cook Islands
Costa Rica
Egypt
Ellice Islands
El Salvador
Ethiopia
Fiji
Gambia
Ghana
Gilbert Islands
Guam
Guatemala
Guyana
Holland
Honduras
Hong Kong
Hungary
India
Indonesia
Iran
Israel
Japan
Kenya
Korea
Kuwait
Lesotho
Liberia
Mainland China
Malaysia
Malawi
Marshall Islands
Mauritania
Mauritius
Mexico
Nepal
New Caledonia
New Hebrides
New Zealand
Nicaragua
Nigeria
North Yemen
Oman
Panama
Papua New Guinea
Paraguay
Peru
Philippines
ROC, Taiwan
Saudi Arabia
Senegal
Seychelles
Singapore
Solomon Islands
Somalia
South Africa
South Yemen
Sri Lanka
Sudan
Swaziland
Tanzania
Thailand
Tonga
Upper Volta
United Kingdom
Uruguay
USA
Venezuela
Vietnam
Virgin Islands

Publications Available

Journal Papers

JP 1 Mackenzie, Photoperiodism of mungbean and four related species

JP 7 Mew, Infectivity and survival of soft-rot in Chinese cabbage

JP 8 Talekar, Persistence of some insecticides in subtropical soil

JP 9 Mew, Effect of soil temperature on resistance of tomato cultivars to bacterial wilt

JP 13 Opeña, Derivation of matroclinical diploids in Chinese cabbage and evaluation of their significance in breeding

JP 27 Kuo, Translocation of 14-C-photosynthate in *Vigna radiata* during the reproductive period

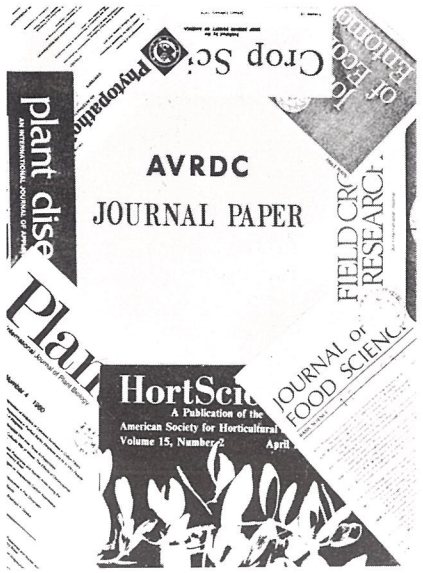
JP 29 Lim, Resistance in Chinese cabbage to TuMV

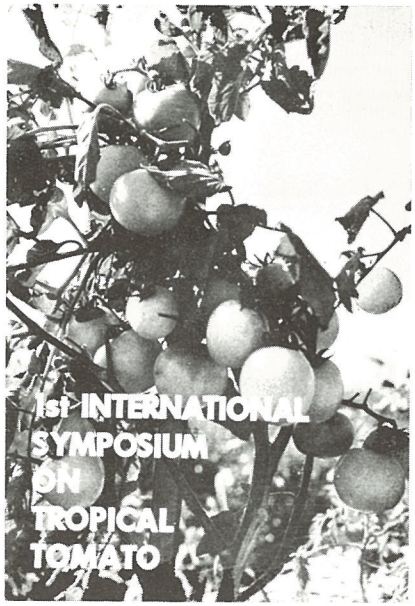
JP 35 Calkins, Labor and input variability in determining vegetable production technology in Asia

JP 40 Villareal, Selection criteria for eating quality in steamed sweet potato roots

JP 48 Riley, Intensive agricultural practices in Asia

JP 50 Hubbell, The Germplasm Accession Information System at the Asian Vegetable Research and Development Center





JP 51 Tschanz, Soybean rust development and apparent infection rates at five locations in Taiwan

JP 53 Kuo, Physiological responses of different tomato cultivars to flooding

JP 54 Kuo, Tipburn of Chinese cabbage in relation to calcium nutrition and distribution

JP 55 Shanmugasundaram, Flower inducing 'potency' of different kinds of leaves in soybean

JP 58 Kuo, Variation in specific leaf weight and RuDPCase activity in mungbean

JP 59 Chiang and Talekar, Identification of sources of resistance to agromyzid beanflies in soybean and mungbean

JP 60 Kuo, Effect of high temperature on pollen grain germination, pollen tube growth and seed yield of Chinese cabbage

JP 61 Kuo, Flower initiation of *Brassica* species under total darkness

JP 62 Villareal, Cultivar response of tomatoes to relay cropping

JP 63 Kuo, Effect of Chinese cabbage residue on mungbean

JP 64 Talekar and Lin, Two sources with differing modes of resistance to *Callosobruchus chinensis* in Mungbean

JP 65 Shanmugasundaram, Varietal differences and genetic behavior for the photoperiodic responses in soybean

JP 66 Kuo et al, Screening for flood tolerance in Genus Lycopersicion

JP 68 Kuo and Huang, Effect of vesicular-arbuscular mycorrhizae on the growth and yield of rice-stubble cultured soybeans

Technical Bulletins

TB 1 Menegay, Taiwan's specialized vegetable production areas

TB 2 Menegay, Farm management research on cropping systems

TB 3 Calkins, Four approaches to risk and uncertainty for use in farm management extension

TB 4 Calkins, Farmer's viewpoint on sweet potato production

TB 5 Calkins, Vegetable consumption in five Taiwan cities

TB 6 Huang, Summer tomato production in Taiwan

TB 7 Huang, Vegetable production in Taiwan: a survey of 300 farmers

TB 10 Calkins, White potato production in Taiwan: a farm survey

TB 12 Riley, Evaluation of environmental parameters in the humid tropics for crop scheduling purposes

International Guide Sheets

78-63 Park, Suggested cultural practices for mungbean

78-64 Park, Procedures for mungbean evaluation trials

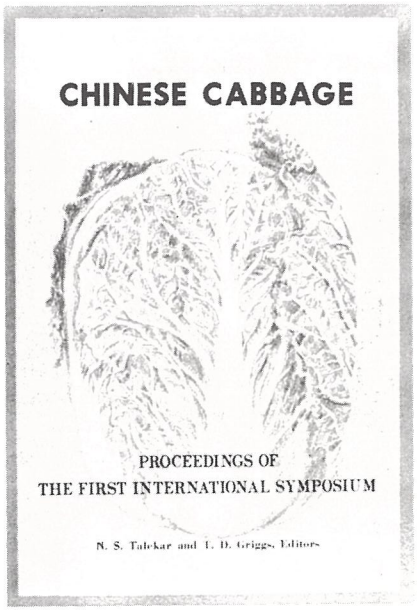
78-65 Villareal, Pollen collector

78-101 Villareal, Procedures to coordinate tomato evaluation trials

78-112 Shanmugasundaram, Suggested cultural practices for soybean

78-121 Hubbell, Suggested cultural practices for sweet potato

79-125 Shanmugasundaram, Procedures for soybean evaluation trials



79-127 Kuo, Suggested cultural practices for tomato

80-134 Villareal, Procedures for sweet potato evaluation trials

80-144 Opeña, Procedures for Chinese cabbage evaluation trials

80-150 Opeña, Cultural practices for Chinese cabbage at AVRDC

Annual Progress Reports

1972-73 Report

1976 Report

1977 Report

1979 Report

Crop Reports

1975 Chinese cabbage

1976 Sweet potato

Miscellaneous

Proceedings of the First International Symposium on Chinese Cabbage

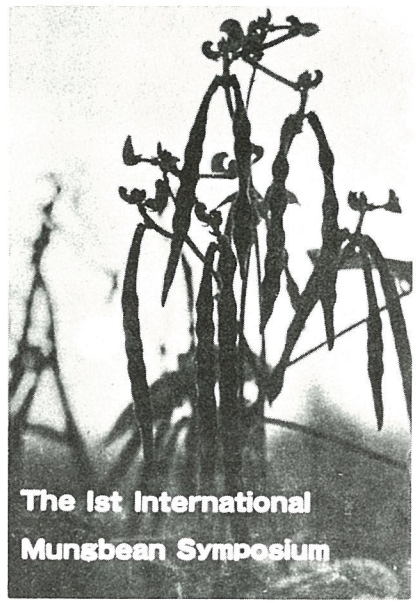
Proceedings of the First International Symposium on Mungbean

Proceedings of the First International Symposium on Tropical Tomato

AVRDC Research Highlights 1980, 1981

Weed Control: Herbicide Evaluation Tests

The AVRDC Training Program



These publications can be ordered from:

The Office of Information Services
AVRDC
P O Box 42, Shanhua, Tainan 741
Taiwan, Republic of China

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Ahn, C. S., H. G. Park and J. L. Tickoo, Genetic resources of mungbean *Vigna radiata* L. Wilczek at AVRDC. FAO/IPBGR *ad Hoc* Working Group on *Vigna*, New Delhi, India, 17-19 September 1981

Chu, C. P., T. Yoshizawa and D. L. Wu, Response of soybean to phosphorus and potassium in relation to soil chemical properties. Conference on Phosphorus and Potassium in the Tropics 'Phospotrops', Kuala Lumpur, Malaysia, 17-19 August 1981

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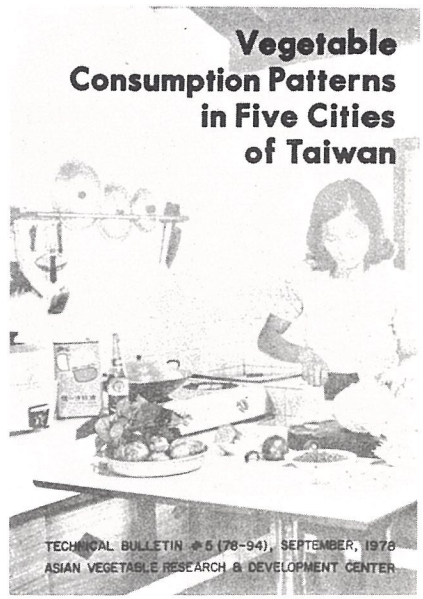

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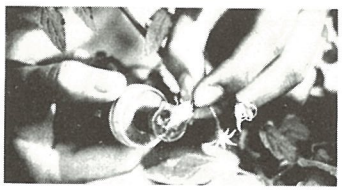

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Anhydrobiosis of the reniform nematode: survival and coiling - B. Y. Tsai

Revolutionary genes in the genus *Lycopersicon* - R. L. Villareal

Breeding strategy for yield improvement of heat tolerant Chinese cabbage - S. H. Lo

The effect of three nitrogen forms on the uptake of ^{45}Ca and ^{86}Rb in tomato seedlings - H. F. Lo

Potential use of extrusion cooking for AVRDC crops - C. Y. Chen

Preparing a prototype training manual - M. C. Ocampo

The effect of source and time of nitrogen foliar application on the yield of Chinese cabbage - A. Baah

Effect of soil additives and fertilizer N on growth and yield of Chinese cabbage and tomato - A. Sajjapongse

India since 1950; an introduction to the successes and failures in agriculture and allied fields - J. L. Tickoo

Interspecific hybridization among four species of the genus *Vigna* Savi - C. S. Ahn

Land reform in Taiwan - J. Tsai

BLISS Level II program: an approach to countryside development -- R. Ramilo

Agriculture in Nepal: an anthropological approach - C. Peet

Biochemical genetics of insecticide resistance in the housefly - T. C. Wang

Cropping Systems involving the five AVRDC crops in Taiwan - Y. C. Roan

The BLISS II tomato project - J. Dongallo

Development of a pilot plant for processing fruits and vegetables - E. M. Baldonado

A proposal for sweet potato improvement for Sumatra - M. Jusuf

An integrated approach on sweet potato production, processing and by-product utilization - L. M. Sanque

Sweet potato as animal feed - S. C. L. Chiu

Advanced yield trials of vegetable soybean breeding lines - R. B. Almodiente

Assessment of protein digestibility for mungbean and blackgram - M. H. Yang

How to control sweet potato weevil - N. S. Talekar

Mungbeans: problems and perspectives - J. L. Tickoo

Anther culture and plant breeding - H. S. Tsay

IBPGR activities on the genetic resources of vegetables - D. H. van Sloten

Diagnosis of plant diseases - A. P. Martinez

Rediscovering the soybean as a vegetable - S. Shanmugasundaram

Frozen vegetable soybean industry in Taiwan - C. P. Liu

The genetics, breeding and physiology of parthenocarpy in *Lycopersicon esculentum* Mill (tomato) - S. S. M. Lin

Adaptation of plants to flooding - G. Kuo

Soil-water management for tomato after rice - F. A. Garcia

Effect of flooding on the physiological and morphological changes of sweet potato and tomato - J. S. Moon

Studies on beanfly infestation of soybean - C. Thepveera

Characterization of podborer resistant soybean accessions - C. Y. Hwang

Effect of flooding and mulching on Chinese cabbage growth and development - K. S. Yoo

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**Arrived during 1981
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Finances

AVRDC's budget for 1981 was US$ 3,342,550 compared to an actual income of US$ 3,072,334 and expenditures of US$ 3,138,620.

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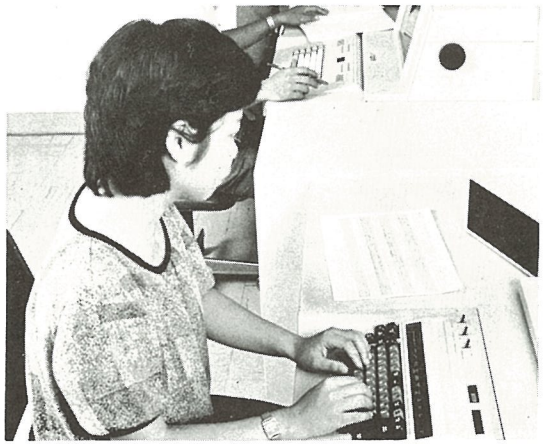

Computer terminal equipment donated by the IBM Taiwan Corporation.

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