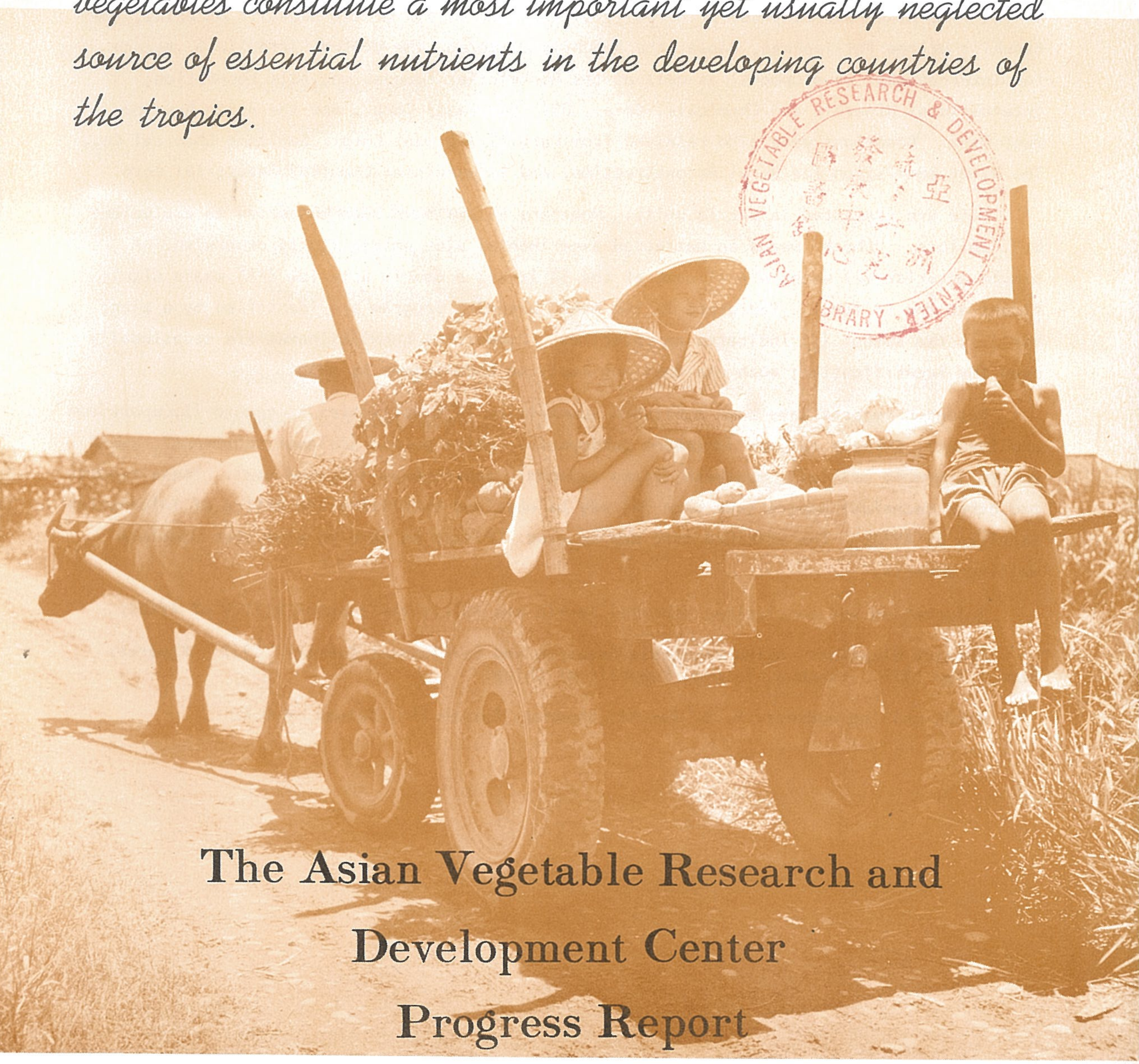
AVRDC PROGRESS REPORT '76

Beautiful children. Healthy and strong in body and mind. Every parent's dream. Diets rich in protein, vitamins, and minerals are essential to the well-being of the growing child whether he lives in Bangladesh or Manila. Paradoxically, vegetables constitute a most important yet usually neglected source of essential nutrients in the developing countries of the tropics.



The Asian Vegetable Research and Development Center Progress Report for 1976

About this report

The 1976 Progress Report summarizes research, training, and outreach activities conducted by the Asian Vegetable Research and Development Center (AVRDC).

AVRDC is the international agricultural research and training organization responsible for improving the production and quality of selected vegetable and legume crops in the humid tropics. The Government of the Republic of China has provided a 116 ha farm located 19 km north of Tainan City in southern Taiwan for AVRDC's experimental and training facilities. During 1976 AVRDC was financed principally by the governments of the Republic of China, the Republic of the Philippines, Japan, the Republic of Korea, the United States (U.S. Agency for International Development) as well as the Rockefeller Foundation, Asia Foundation, International Minerals and Chemicals, Corp., USI (Far East) Corp., and the Asian Development Bank. Donations were also received from Cargill (Taiwan) Corp., Sumitomo Chemical Co., The Joint Commission for Rural Reconstruction, and Taiwannissan Chemical Industrial Corp.

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

Research reports have been published summarizing 1976 activities in tomato (*Lycopersicon esculentum*), Chinese cabbage (*Brassica pekinensis*), white potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), mungbean (*Vigna radiata*), and soybean (*Glycine max*). These reports and other technical papers (see page 76) may be obtained by writing the Office of Information Services at AVRDC. The attached card may be used. Please be sure to give your complete mailing address.

Information and conclusions reported herein are solely the responsibility of AVRDC.

Correct citation: Asian Vegetable Research and Development Center. 1977. Progress Report for 1976. Shanhua, Taiwan, Republic of China.

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

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Director's foreword

The 1976 Progress Report reflects a continuing high level of accomplishment by the AVRDC staff. Research progress in all six crops is carefully documented. The growth and development of our training program in its first year of full-scale operation is also reported.

Of particular significance during the year was the adoption of AVRDC vegetable varieties by farmers in a number of countries. Linkages developed between our scientists and national programs encouraged a commercial producer and small scale packer in the Philippines to grow AVRDC tomato lines. A Malaysian farmer produced enough tomatoes from our introductions to export for fresh market and hotel use to Hong Kong and Singapore. Additional examples of successful adoption and recommendation of AVRDC materials and practices can be found for mungbean and soybean. These developments indicate the maturity of the AVRDC research programs, the soundness of the approaches used for problem identification, and the staff's enthusiasm for solving vegetable production problems in the Asian tropics.

During 1976, AVRDC conducted 17 conferences at Shanhua and members of the staff attended 20 others which included international participation. The Center held a conference on vegetable information and documentation. A workshop on the soybean rust disease was held in Manila and sponsored by INTSOY, PCARR, and AVRDC. And a planning Conference on Pre- and Post-harvest Vegetable Technology, held in Los Baños, the Philippines, was attended by national leaders from nine Asian countries.

AVRDC publications are being requested by an expanding circle of readers in 132 countries. The total readership exceeded 4200 in July plus 642 libraries or institutional documentation centers.

AVRDC continues to operate on an inadequate budget but has gained increased support from sources which approximately balance declining contributions from other donors and inflationary losses of real value. Nevertheless, the Center will continue to function as an independent international tropical agricultural research and training institution governed by a Board of Directors representing donors and scientific management expertise in the region. We are gratified by the acceptance of the Center's work by the scientifc community and by national leaders sincerely interested in helping both the small farmer and the poorest urban dweller despite political constraints said to be associated with our location.

AVRDC is grateful to its many supporters yet hopes that the number of contributors will expand during the coming year. We encourage interested persons and institutions to contact us regarding ways in which we can work together to assist the vegetable growers in Asia and around the world.

James C. Moomaw

James C. Moomaw
Director

The Asian Vegetable Research and Development Center Progress Report for 1976

Introduction

"Amidst the thousands of defeated, emaciated refugees, a woman lies on the station platform and gives birth. Several other women come to her aid. One finds a rusty sickle near the tracks and cuts the umbilical cord. Another, seeing the mother is too weak and shriveled to nurse, dabs the infant's lips with coarse table sugar. burning with fever, the helpless mother watches. Bangladesh has another mouth to feed." (Steve Raymer, 1975)[+]

In every country; throughout history; regardless of class, religion, or politics, children are the hope of mankind. And, yet, this birth in a Bangladesh train station provides a harsh reminder that similar tragedies occur every day in countries around the world, and more frequently in the developing nations. The children, if they survive, very often grow up only to swell the ranks of the world's hopeless and miserable majority. Hunger will be their constant companion; disease, the silent partner in every act.

Malnutrition takes several forms and has many causes with only one known cure -- an adequate and well-balanced diet. It is not sufficient to consume an adequate quantity of food; we must also be concerned with food quality if we wish our children to progress with the ambitious goals of national development. Far too many children in the developing countries are doomed by malnutrition to lives of irreversible physical and mental damage. Even babies who receive adequate nutrition while being breastfed, often become malnourished after weaning because of the change from mother's milk to a diet of cheap, starchy, nutritionally incomplete foods such as rice gruel, cassava, and bananas. Their tiny stomachs will not hold enough of these bulky staples to provide an adequate supply of protein and other essential vitamins and minerals. Such diets during the early years of life impair the development of the brain and central nervous system, thus preventing the realization of genetic potential and permanently retarding learning capacity. The problems of nutrition are fundamental to every human activity and demand immediate and concerted attention worldwide.

The scientists at the Asian Vegetable Research and Development Center (AVRDC) have been charged with the vital task of developing appropriate technologies and improving production of six vegetable crops in the hot, humid lowland tropics. Although rice is the principal food staple in these lands, AVRDC's vegetable crops are effective nutritional supplements to a rice diet as they supply plant protein, vitamins, and minerals. Additionally, these vegetables offer Asian farmers opportunities to increase their incomes and, thereby, enhance the quality and security of their lives.

[+]Steve Raymer. 1975. The nightmare of famine. National Geographic, 148(1):34.

Market scene in
Papua New Guinea.
Mother selling
a few vegetables
while baby sleeps.

Completing our fourth research year with the 1976 fall season, AVRDC is proud to report significant progress. However, despite the continuing work of agricultural scientists, extension workers, and farmers, the gap between food supply and demand in the tropics continues to widen.

The annual per capita production of the six crops receiving major attention at AVRDC has been relatively stagnant in the developing countries during this past decade (Fig. 1). Yet, this is the same decade which saw dramatic breakthroughs in wheat and rice production. Unfortunately, the contributions of vegetable crops to national economies in Asia are all but imperceptible in terms of the production indicators used for cereal crops. This phenomenon is partially the result of the small plots on which vegetables are grown and tends to reinforce the low priority assigned to both vegetable production and vegetable research in the tropics. However, vegetables are of greater significance on the farmer's horizon than is often perceived.

Furthermore, the per capita production of these crops in the so-called developing market economies (located, for the most part, in the tropical regions of Asia, Latin America, and Africa) is substantially lower than in either the developed or centrally planned market economies, with the exception of 'dry beans' -- a FAO designation which includes mungbean.

Per capita production of white potato decreased by 13% worldwide between 1965 and 1974. There was little production change in the developing countries and output remained about 10 to 11 kg/person per year -- approximately a tenth of the amount produced in the developed countries.

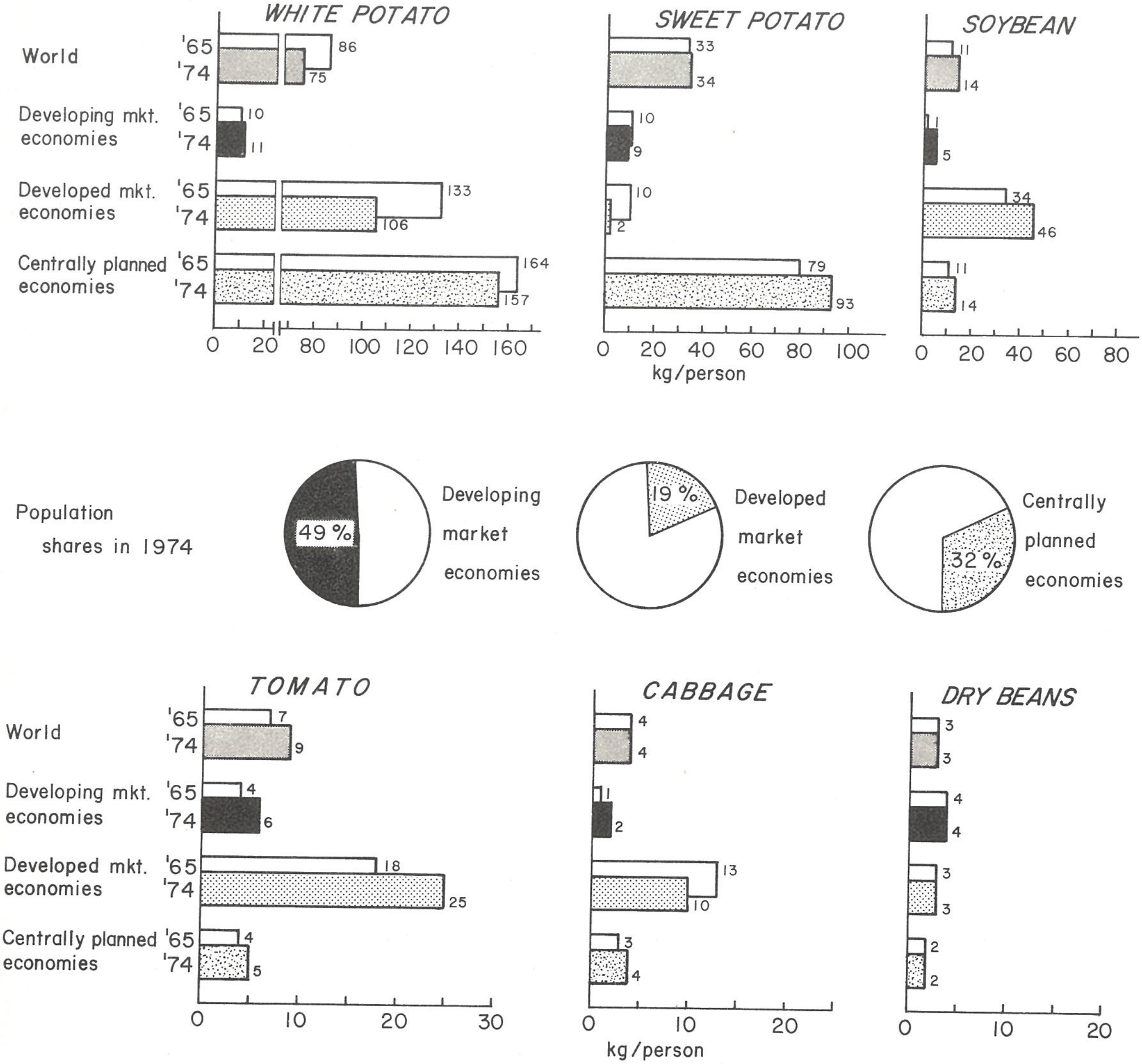


Fig. 1. Per capita production of AVRDC's six crops for 1965 and 1974 for the world and FAO-designated economy groupings compared with the population shares of the three economies. Source: FAO Production Yearbooks, 1970 through 1974.

Although sweet potato is considered a "poor man's food," annual per capita production in the developing countries is less than a third of the world total and decreased slightly during the period under study. Greater research and extension efforts are needed if this important root crop is to make its potential contribution in reducing world food shortages.

An undisputed source of plant protein, soybean is primarily grown in the United States. In recent years, Brazil has rapidly expanded soybean production and accounted for 80% of the 5 kg/person produced in the developing countries in 1974. Although an inexpensive source of protein is vital to the diet of millions in the developing countries, most of their soybean crops is channeled into export markets.

Tomato increased in worldwide annual per capita production between 1965 and 1974. This fruit, nutritionally recognized for its high vitamin A and C content, also lends itself to a number of processing uses. However, in 1974, per capita tomato production in the developing countries amounted to less than a fourth of that in developed countries.

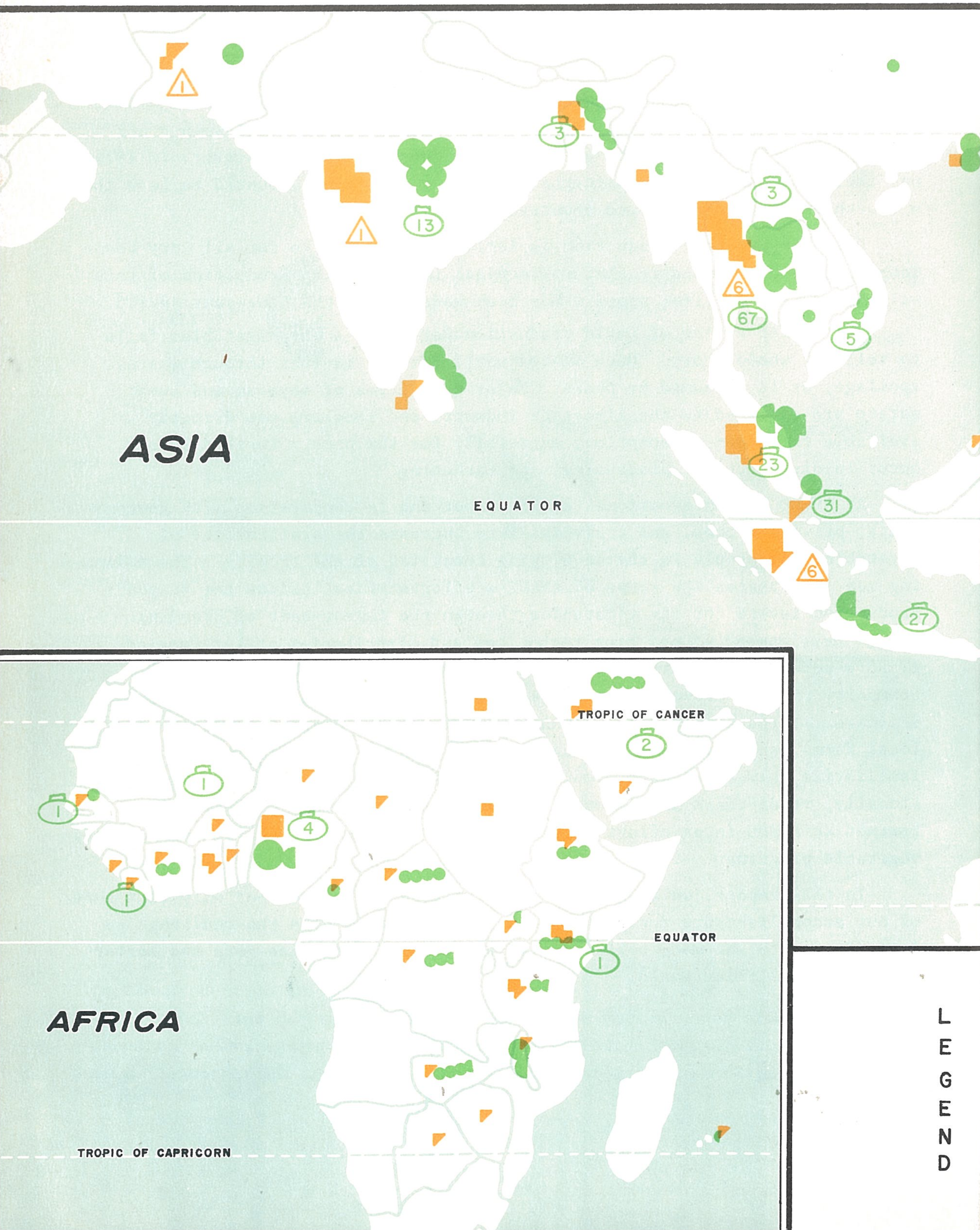
Data for mungbean production is included with figures for all dry beans However, the data indicate that no increase in per capita production of this valuable source of plant protein has been made during the nine-year period.

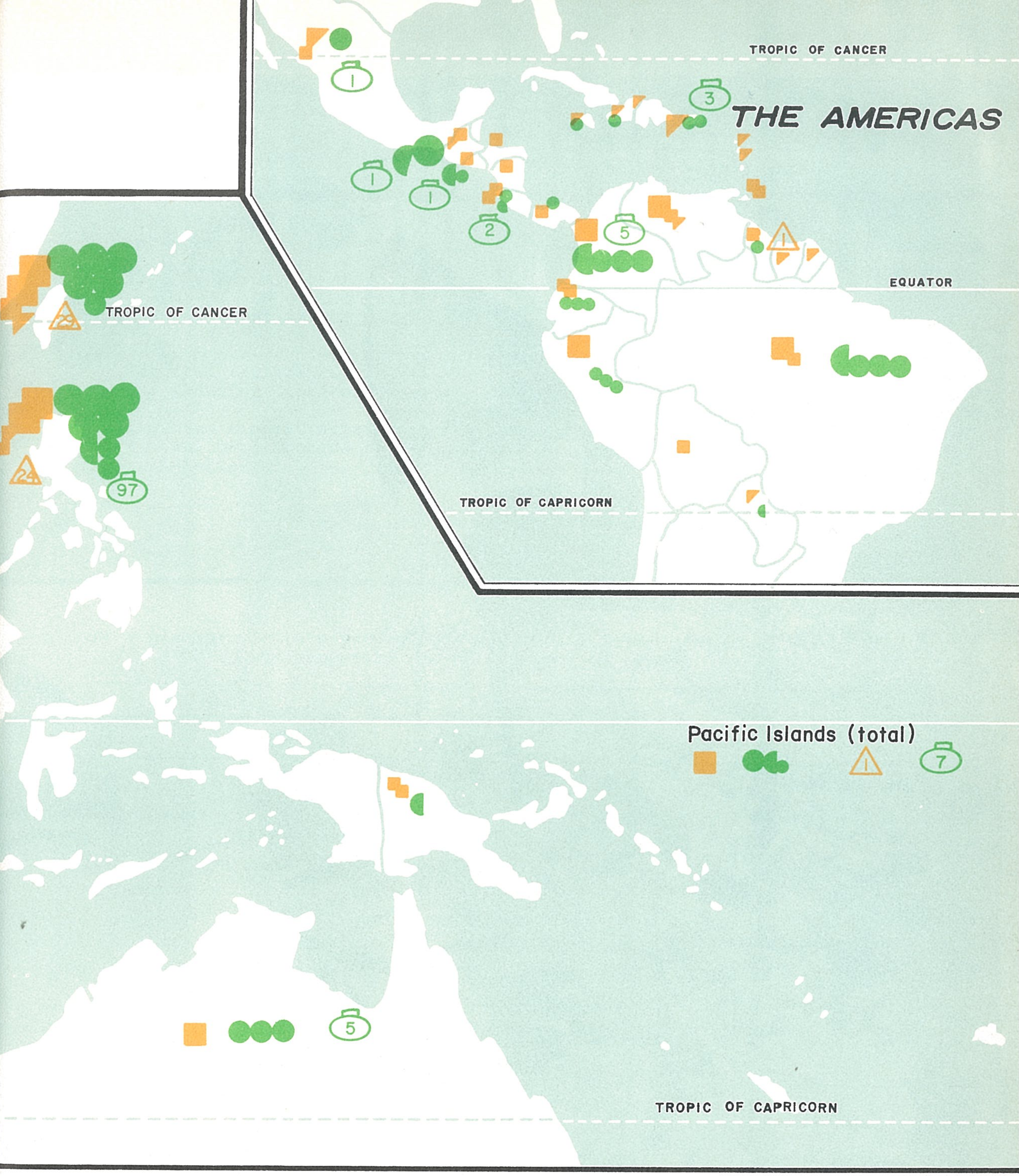
This brief review of world production for AVRDC's six vegetables fails to tell the whole story. Much of the world harvest is lost through waste, spoilage, or is consumed by pests. Major quantities of soybean and sweet potato are diverted to the livestock industry and thus are not directly available for human consumption, especially for the poor. Further losses occur in distribution, processing, and marketing.

At AVRDC, an international staff is working in cooperation with governments, private groups, and individuals to increase the availability of vegetables for people in the developing countries of the tropics. The following map illustrates the scope of AVRDC's efforts to revitalize the stagnant production levels for six vegetables through the improvement of breeding lines, development of new crop technology and distribution of information. AVRDC's scientists maintain contact with the international agricultural community through travel and participation in conferences, workshops, and seminars. Through visits to national researchers, cooperative trials on local farms, and involvement in agriculture-related activities, the scientists familiarize themselves with production practices and constraints. Additionally, researchers and production specialists from many countries are trained at AVRDC in an effort to directly improve the capabilities of national vegetable programs.

In this report, we at AVRDC would like to acquaint you not only with some of our accomplishments during the past year, but also with the challenge we face along with our many colleagues in the effort to produce more and better food for a healthier world.

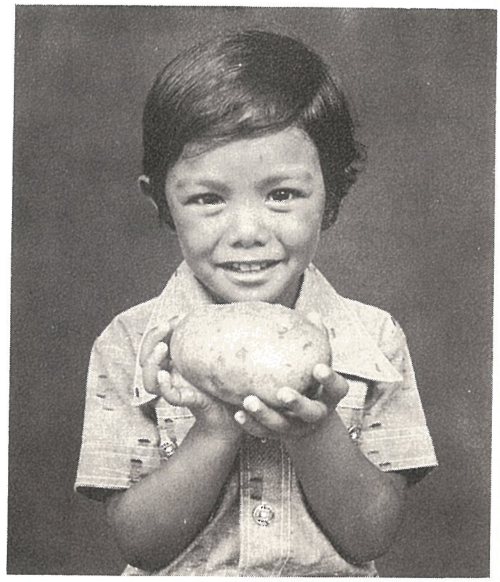
AVRDC IN THE TROPICS (1973 - 1976)





No. on mailing list	No. of seed packets	No. of trainees	No. of staff trips
■ = 10	● = 10	△ 2	7
■ = 50	● = 100		
■ = 100	● = 1000		

White Potato



WHITE POTATO RESEARCH OBJECTIVES

*Greater formation and expansion of tubers under conditions prevalent in the humid lowland tropics

*Varietal resistance to yield reducing tropical diseases

*Improved mineral nutrition and cultural methods for higher yields

At a glance: White potato yields and population growth of selected tropical and temperate countries; 1965 to 1974.[a]

Country	Ave. yield 1965	Ave. yield 1974	Change in yield	Population growth; 1965 to 1974
	-----(t/ha)-----		(%)	(%)
Bangladesh	7	9	29	37
Burma	3	5	67	23
Cameroon	5	3	-40	21
Cuba	6	5	-17	17
Ethiopia	5	5	0	21
India	8	9	12	21
Indonesia	4	4	0	30
Philippines	7	7	0	35
Thailand	5	7	40	34
Uganda	5	5	0	27
Japan	19	22	16	11
Netherlands	26	35	35	10
U. S. A.	24	28	17	9

[a]Data from FAO Production Yearbooks, 1970 through 1974.

The collection of *Solanum* germplasm during 1976 was limited to true seeds, which are considered to be segregating populations. Six new populations of *tuberosum/vernii* combinations backcrossed several times to *tuberosum* were received from the Max Planck Institute in Germany.

New populations for recurrent selection were developed by intercrossing 6 of our more promising selections in diallel (excluding reciprocals) fashion. The 6 parents were the highest yielders in two 1975 trials conducted in the Philippines (Table 1).

Table 1. Marketable yields in two trials of the best 6 white potato selections used as parental clones for recurrent selection; 1975, Philippines.[a]

AVRDC selection no.[b]	Mean Yield	Yield	
		Davao City	La Granja
	(t/ha)		
1282-1	16	22	11
1284-18	15	18	12
1282-5	14	16	12
1284-5	13	20	7
1282-4	13	17	9
1284-15	13	16	10

[a]Planted Sep 20 and harvested Dec (1975) at Twin Rivers Research Center (TRRC) near Davao City, Mindanao, Philippines (min temp >20°C); and Oct 27 to Jan 27 (1975) at the UP La Granja Research & Training Center near La Carlota City, Negros Occidental Philippines. [b]Genetic material selected from populations obtained from the Univ. of Guelph in Canada.

Five cycle 2 populations were immediately developed from the cycle 1 selections and grown for further selection in Davao City Jan 3. The yield advance of selections from the 5 populations ranged from 67 to 226% of the cycle 1 parents (Table 2). The best selection produced 1.5 kg of marketable yield per plant in 88 days.

More than 16,400 clones originating from AVRDC crosses and populations received as true seed were screened for heat tolerance during the summer at AVRDC. We made 42 selections from AVRDC crosses (Table 3). Analysis of total glycoalkaloid (bitter) content reduced the number to 11 selections with good yield potential and fairly low solanine content. The 5 best yielding selections are listed in Table 4. Two of these selections also had solanine content below the acceptable 20 mg/100 g level.

While screening our germplasm for photoperiod insensitive clones, we observed that long days had almost the same effect on vegetative growth as high temperatures, i.e., both significantly increased plant height and internode length and reduced both haulm growth and the length and width of terminal leaflets. Although photoperiod insensitive clones

Table 2. Results of 2 cycles of recurrent selection to improve white potato under hot, humid tropical conditions; 1974-76, AVRDC and the Philippines.

Population no.	Mean marketable yield: cycle 1 selections AVRDC[a]	TRRC[b]	cycle 2 selections[c]	best cycle 2 clone	Approx yield advance[d]
	(g/plant)				(%)
8	244		412	525	69
9	372	368	1200	1500	226
21	352	462	880	1148	90
23	351	469	813	950	67
33	310	405	857	1300	112

[a]Screened in summer of 1974 at AVRDC. [b]1975 trial at TRRC near Davao City, Philippines. [c]1976 planting at TRRC. [d]Mean yield of cycle 2 selections divided by mean yield of cycle 1 selections at TRRC except for population 8.

Table 3. List of white potato segregating populations screened for heat tolerance during the summer; 1976, AVRDC.[a]

Population	Families	Clones	Emergence	Survival	Selections
	(no.)		(%)	(%)	(no.)
AVRDC crosses[b]	52	4,339	83	45	42
CIP crosses[c]	35	2,169	86	37	0
Andigena	49	609	71	32	0
Andigena/tuberosum	21	3,365	86	25	0
Phureja-stenotomum	97	5,948	65	3	0
Totals	254	16,428			42

[a]Planted Jun 20 and harvested Oct 3. [b]Progeny of intercrosses of selections from populations with wild species background obtained from Univ. of Guelph. [c]Populations obtained from the International Potato Center (CIP), includes 6 received in 1975.

generally performed better than sensitive clones under hot, humid conditions, the relationship between photoperiod insensitivity and heat tolerance was not close enough to be a useful screening criterion by itself.

Phenotypic correlation analyses among clones of AVRDC's white potato selections (derived from Guelph populations) showed that performances in the warm and cold seasons at AVRDC were positively correlated for these clones (Table 5).

Table 4. Yield and solanine content of the best 5 white potato selections from AVRDC crosses; 1976, AVRDC.[a]

AVRDC selection no.	Yield		Tuber		Solanine content
	total	marketable	total	marketable	
	(g/clone)		(no.)		(mg/100g)
75-0-827-102	1000	780	14	7	29
39-1-106	760	710	12	7	32
57-0-893-237	660	660	6	6	12
75-0-8212-103	900	660	16	7	12
33-15-140	830	640	33	12	31

[a]Planted Jun 20 and harvested Oct 3.

Table 5. Simple phenotypic correlations (r) between winter and summer data on yield and other characters among white potato selections; 1976, AVRDC.[a]

Winter data	Summer data			
	total yield	marketable yield	tuberization efficiency	haulm growth
Total yield	0.33*	0.39*	0.37*	ns
Marketable yield	0.37*	0.44*	0.36*	ns
Tuberization efficiency	ns	ns	0.58**	-0.56**
Haulm growth	ns	ns	-0.41*	0.45**

[a]* and ** indicate significant correlations at 5 and % levels, respectively. ns = not significant.

Nine cultivars were selected for testing in a preliminary yield trial conducted at AVRDC during the 1975-76 winter season to isolate high yielding clones having resistance to late blight (*Phytophthora infestans*). In a spring trial conducted in central Taiwan, 2 AVRDC selections significantly outyielded the local cultivar, Nohrin 1 (Table 6).

Five selections averaged more than 400 g of marketable yield per plant in a preliminary summer yield trial involving 107 breeding lines and cycle 2 populations on a farmer's field in Tashe (near AVRDC, sandy loam soil), Taiwan (Table 7). Four of the 5 clones had not been tested elsewhere. They may possess greater yield potential than those listed in Table 1 that were tested earlier in the Philippines.

Eight cultivars and 9 breeding lines were resistant to late blight in a screening conducted in cooperation with the Taiwan Seed Service in central Taiwan. Two breeding lines

Table 6. Yield data of the best white potato selections compared to Nohrin 1 in a spring yield trial; 1976, Central Taiwan.[a]

AVRDC selection no. (or cultivar name)	Yield marketable	Yield total	Marketable to total yield ratio	Marketable tuber
	----------(t/ha)--------		(%)	(no./plant)
1491-4	17	26	66	3
1282-14	17	23	73	2
1513-1	15	25	59	3
1511-3	14	23	62	2
1491-3	14	24	56	2
1282-7	12	30	42	2
1522-1	12	18	71	2
(Nohrin 1)	11	19	54	2
HSD 5%	5	4		

[a]Planted Dec 30 (1975) in a farmer s field in Fengyuan in central Taiwan with 2 replications. Harvested early on Mar 24 (84 days after planting). Experiment in cooperation with Fengyuan Farmers' Associations.

Table 7. Mean yields and other horticultural traits for the best 5 white potato selections compared to values for Nohrin 1 in a summer trial; 1976, Tashe near AVRDC.[a]

AVRDC selection no. (or cultivar name)	Hills harvested	Yield marketable	Yield total	Tubers marketable	Tubers total	Haulm growth	Tuberization efficiency[b]
	(no.)	---(g/plant)----		(no./plant)		(g/plant)	
1282-17	9	600	840	5	12	700	1.2
11R-10	10	511	911	5	18	860	1.1
11R-2	15	409	672	4	14	761	0.9
1282-19	15	409	716	4	14	788	0.9
1282-15	10	401	666	3	12	800	0.8
(Nohrin 1)[c]	12	80	203	1	5	262	0.8

[a]Planted Jun 25 in 3-m single row plots with 2 replication and harvested Oct 20 (120 days).
[b]Total yield divided by haulm growth. [c]Heat-sensitive check.

(1282-3 & 1282-16) were consistently resistant to southern blight (*Sclerotium rolfsii*) in spring and fall trials.

While attempting to determine the suitable tuber size for comparable enzyme activity studies, we observed that the enzymes sucrose synthetase, UDPG pyrophosphorylase, and soluble starch synthetase increased with increasing tuber size, whereas ADPG pyrophosphorylase and granular starch synthetase remained relatively constant. Phosphorylase activity decreased as tuber size increased.

Sucrose synthetase and UDPG pyrophosphorylase enzyme activities decreased when the heat-sensitive cultivar Nohrin 1 was grown under high night temperatures, but increased slightly for the heat-tolerant selection 1284-5 under the same conditions. The changes in the activities of these 2 enzymes, thus, may reflect the variations in tuber growth at high night temperatures.

By conducting reciprocal grafting experiments between heat-tolerant and heat-sensitive clones, we found that high night temperature limited tuber growth more through its effects on the shoot (haulm) than on the tuber itself (Table 8).

Table 8. Effect of different night temperature conditions on the yield and growth rates of reciprocal graftings between a heat-sensitive cultivar (Nohrin 1) and a heat-tolerant selection (1284-5); 1976, AVRDC.

Entry (scion & stock)	Night temp treatment				Growth period after grafting
	20 to 25°C		15 to 20°C		
	yield	daily growth rate	yield	daily growth rate	
	(g/plant)				(days)
Nohrin 1 & 1284-5	23	0.38	44	0.74	60
1284-5 & Nohrin 1	50	0.83	42	0.70	60

Follow-up growth analysis studies determined that the relative growth rate (RGR) and net assimilation rate (NAR) decreased at tuber initiation and then increased for a short time in Nohrin 1 and a longer period in selection 1284-5. Within the same variety, high night temperature tended to reduce both RGR and NAR. The leaf area of Nohrin 1 was substantially reduced under high night temperature conditions, whereas that of selection 1284-5 was not greatly affected.

When clones of Nohrin 1 were grown under high night temperatures, they accumulated less soluble sugar and starch in the different plant parts compared to clones grown under lower temperature conditions. No differences were observed for the heat-tolerant selection 1284-5.

The concentration and distribution of potassium, an element reported to influence the translocation processes of white potato, did not differ significantly for either Nohrin 1 or selection 1284-5 when grown under high and low night temperatures. This result suggests that potassium may not be a major limiting factor in tuber enlargement under high night temperature conditions.

We measured the net photosynthetic rates (NPR) of leaf disks at varying in vitro temperatures and found the NPR to be lower on plants grown under high temperatures. Nohrin 1 grown under high temperature conditions had the highest dark respiration rate at all in vitro temperatures. In another experiment using infra-red gas analysis, we observed that the NPR was reduced in Nohrin 1 and increased in the heat-tolerant selection 1284-3 as leaf chamber temperatures increased.

We examined the nutritional quality of 90 white potato breeding lines grown under hot, humid summer conditions and found the following:

1) Dry matter content was normally distributed around a mean of 19% with a range of 13 to 26%. The mean reported for potatoes produced during the cold season in Taiwan is 22%.
2) Vitamin C content was also normally distributed with a range of 11 to 38 mg/100 g fresh weight and a mean of 25. This mean was substantially higher than the mean (7 mg/100 g fresh wt) reported for local winter production.
3) The mean protein content was 2.3% and ranged from 1.3 to 4.4% on a fresh weight basis. The mean was the same as that reported for local winter production.
4) Total glycoalkaloid (TGA) content among the breeding lines was as high as 77.5 mg/ 100 g fresh weight. However, a large proportion of the selections had a low TGA content, i.e., 53% were below 20 mg and 32%, below 10 mg.

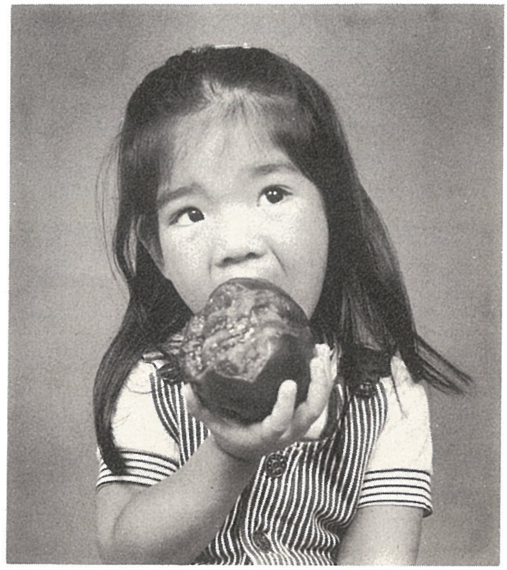
In a trial conducted through AVRDC's Outreach Program in the Philippines (at Los Baños), all 11 cycle 1 selections produced substantially higher yields than 3 local cultivars. The mean yields per plot of the best 6 selections are compared to the local cultivar Fina in Table 9.

Table 9. Mean yields of 6 white potato (cycle 1) selections compared to the local cultivar Fina in a fall trial; 1975-76, Philippines.[a]

AVRDC selection no. (or cultivar name)	Mean yield		Plants surviving to harvest[b]
	(t/ha)	(g/plant)	(%)
1284-19	10	281	70
1282-16	7	201	80
1282-15	7	163	70
1282-18	6	300	50
1282-4	6	213	70
1487-5	6	162	80
(Fina)	1	65	30
LSD 5%	3	87	

[a]12 entries were planted Nov 17 (2975) and harvested Jan 20 (64 days) at Bureau of Plant Industry Economic Garden, Los Banos, Philippines; 1.5 m by 1.5 m plots; 2 replicates.
[b]Bacterial wilt (*Pseudomonas solanacearum*) was a serious problem in this trial.

Tomato



Tomato Research Objectives

*Greater yields under the humid conditions of the lowland tropics

*Varietal resistance to bacterial wilt, tomato mosaic virus, late blight, and other tropical diseases

*Increased size and quality of tomatoes produced during the hot season for both the fresh market and processing

*Development of management practices to permit genetically improved cultivars to flourish under tropical monsoon conditions

At a glance: Tomato yields and population growth for selected tropical and temperate countries; 1965 to 1974.[a]

Country	Ave. yield 1965	Ave. yield 1974	Change in yield	Population growth; 1965 to 1974
	------(t/ha)------		(%)	(%)
Bangladesh	6	8	33	37
Cuba	5	6	17	17
Ghana	5	5	0	33
India	9	9	0	21
Nigeria	10	10	0	26
Philippines	4	6	50	35
Sri Lanka	2	2	0	24
Thailand	3	3	0	34
W. Malaysia	5	5	0	27
Netherlands	90	133	48	10
Japan	28	48	71	11
U. S. A.	30	39	30	9

[a]Data from FAO Production Yearbooks, 1970 through 1974.

We have now screened a total of 4050 cultivars for heat tolerance, i.e., ability to set fruit when night temperatures are higher than 22°C. Another 8 cultivars were selected for heat tolerance in 1976 for a total of 38 heat-tolerant cultivars (1% of the total screened), which set fruit abundantly during the summer monsoon season (Table 1).

Table 1. Distribution of tomato germplasm according to fruit-setting ability when minimum night temperatures were above 22°C; 1976, AVRDC.

Observed fruit-setting	Screening previous	Screening 1976[a]	Total	Proportion
	(no. of cultivars)			(%)
None	3058	134	3192	79
Light	548	74	622	15
Moderate	163	35	198	5
Heavy	30	8[b]	38	1
Totals	3799	251	4050	100

[a]Planted in 6 sets from Jul 8 to 15; 4-m^2 plots; 2 replicates. [b]PI 341155 was especially noteworthy as its fruits are much larger than the other heat-tolerant cultivars.

Breeding lines possessing both heat tolerance and resistance to bacterial wilt (*Pseudomonas solanacearum*), gray leaf spot (*Stemphylium solani*), leaf mold (*Cladosporium fulvum*), and tomato mosaic virus (TMV) have been developed at AVRDC and were highly superior to local cultivars in a series of cooperative trials in Indonesia, Malaysia, the Philippines, Thailand, Singapore, Sri Lanka, Guam, and Taiwan (Tables 2 & 3). Other breeding materials were selected for resistance to either TMV or late blight (*Phytophthora infestans*).

Table 2. Yield and survival rates of various AVRDC tomato breeding lines compared to the commercial cultivar Roma; 1976, West Malaysia.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield	Survival rate[b]
		(kg/plot)	(%)
122-0-1-8	ahTM2a/VC 11-1	9	22
32d-0-1-2	VC 9-1-2-3/Venus	8	47
30-0-4-17	VC 49-1-1/Saturn	8	48
103-0-5-4	Roma/VC 48-1	4	27
32d-0-1-1	VC 9-1-2-3/Venus	3	40
103-0-5-3	Roma/VC 48-1	3	12
123-4-11	ahTM2a/VC 8-1-2-1	2	0
(115)	(Roma)	0	0
LSD 5%		3	

[a]Data provided by Dr. T. S. Tee and Miss Melor Rejab of MARDI. Planted in the peat soils of Jalan Kebun Experiment Station. Data are means of 3 replications. [b]Natural epiphytotics of bacterial wilt.

We were greatly encouraged by the performance of 50 F_5 genotypes of the SSD (single seed descent) breeding line 555 (VC 8-1-2-1/Saturn// Kewalo) in a replicated trial at the MARDI Jalan Kebun Experiment Station in Malaysia. Dr. T. S. Tee selected the best 7 genotypes (Table 4) based on resistance to bacterial wilt, fruit size, and heat tolerance. From

Table 3. Yields of AVRDC breeding lines in 3 trials conducted by different institutions in the Philippines; 1975-76, Philippines.

BPI Economic Garden, Los Baños[a]		Mindanao Institute of Technology, N. Cotabato[b]		Central Luzon State Univ., Nueva Ecija[c]	
AVRDC selection no. (or cultivar name)	marketable yield	AVRDC selection no. (or cultivar name)	marketable yield	AVRDC selection no. (or cultivar name)	marketable yield
	(t/ha)		(t/ha)		(t/ha)
32d-0-1-15-0	43	32d-0-1-4-0	33	11d-0-1-2-0	39
32d-0-2-4-0	43	32d-0-1-15-0	17	143-0-4b-1-0	36
32d-0-1-25-0	43	32d-0-1-1-0	16	(VC 8-1-2)	32
8d-0-0-1-0	42	32d-0-1-25-0	13	122-0-3-4-0	30
(Improved Pope)	34	(VC 11)	12	(VC 20-29)	27
Grand mean	30 (30 entries)		8 (30 entries)		26 (21 entries)
LSD 5%	10		7		8

[a]Planted Dec 9 (1975); 9.6 m^2 plot; 3 replications. [b]Data supplied by Dr. R. T. Gloria and Mr. D. Oria; trial planted Dec 23 (1975); 8 m^2 plot; 3 replications. [c]Data supplied by Dr. F. F. Campos and Ms. A. Macasa; trial planted Feb 4; 5.2 m^2 plot; 3 replications.

Table 4. Yields and survival rates of the best SSD F_5 lines from VC 8-1-2-1/Saturn// Kewalo in a preliminary trial; 1976, MARDI, Malaysia.[a]

AVRDC SSD no.	Yield per plant	Yield per ha[b]	Survival rate[c]	Fruit size	Days to flowering
	(g)	(t)	(%)	(g)	(no.)
12	728	36	98	26	25
47	496	24	98	27	29
16	484	24	95	27	23
18	478	24	100	45	30
29	376	19	98	41	34
39	333	16	100	36	29
45	318	16	95	38	29

[a]50 genotypes were planted Jul 12 by Dr. T. S. Tee and Miss Melor Rejab of MARDI at the Jalan Kebun Experiment Station; Data are means of 40 to 60 plants. This was the first successful use of the SSD (single seed descent) method for rapid generation advance involving 3 sources of resistance to *P. solanacearum*. [b]Plant population was 49,383 plants/ha. [c]Under natural epiphytotics of *P. solanacearum*; the locally grown cultivar, Red cloud, had a zero survival rate.

these lines, at least two will be chosen and seed will be multiplied for distribution to farmers. These lines should offer considerable improvement over the present practice of grafting tomato to wilt-resistant eggplant stock. This was the first successful use of the SSD method for rapid generation advance involving 3 sources of resistance to bacterial wilt.

Two of our breeding lines (122-1-1 and 126-7-1) were field resistant to a serious outbreak of double streak virus (a combination of TMV and potato virus x) in a yield trial planted in March at AVRDC.

We also identified new sources of resistance to *P. solanacearum*, *S. solani*, *C. fulvum*, *Alternaria solani* (early blight), *P. infestans*, *Erysiphe polygoni* (powdery mildew), and *Meloidogyne* sp. (root-knot nematodes) in our *Lycopersicon* sp. germplasm collection.

A series of crop management experiments conducted during the summer have led us to believe that another primary problem limiting summer tomato production in the lowland tropics is related to poor soil drainage and insufficient levels of oxygen in the soil. This restricts root respiration and the metabolic absorption of water during periods of intense and prolonged rainfall. The application of compost to the tomato beds improved root size and growth (Figs. 1 & 2). In addition, soil preparation techniques that preserved soil structure such as moldboard plowing with a buffalo were observed to be superior to using a power tiller.

Our physiologists found that the recovery rate of tomato plants waterlogged for 3 days was substantially improved by foliar application of the hormone benzyladenine in a greenhouse experiment.

We observed a varietal response among selected tomato cultivars and breeding lines to higher levels of both nitrogen and compost during the fall and winter seasons on AVRDC's calcareous soils.

Fig. 1. Poor development of tomato roots in control (no compost) plots; 1976, AVRDC.

Fig. 2. Vigorous development of tomato roots when grown in soil that has been improved with compost; 1976, AVRDC.

Work was begun on the development of evaluation criteria for the fruit quality of tomato produced during the summer for both the fresh market and the processing industry. Our preliminary analysis, based on weekly harvests throughout the summer season, indicate that the potential for good fruit quality exists within our breeding materials.

We developed a handy, light (150 g), and compact pollen collector (Fig. 3), which facilitates hybridization efforts with tomato and other crops with flowers of similar size or larger. Plans of this modified pollen collector are available upon request.

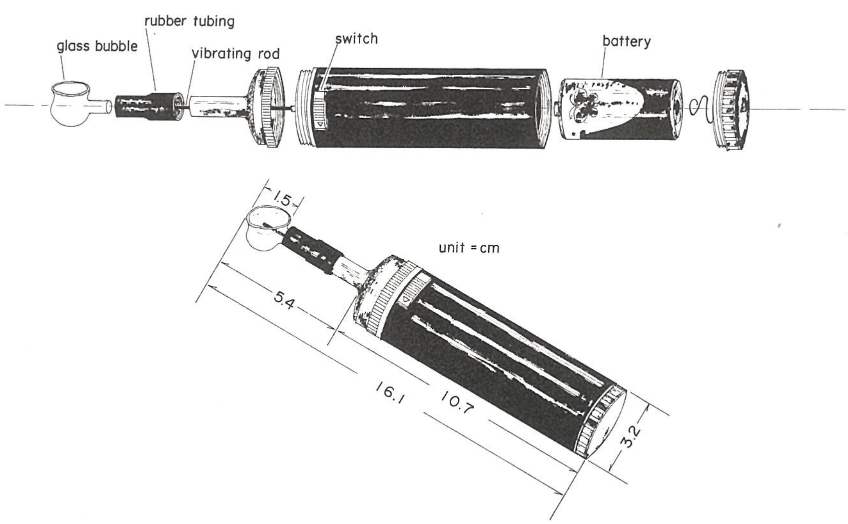


Fig. 3. Modified pollen collector developed by tomato breeders; 1976, AVRDC.

In winter yield trials of processing tomato breeding lines at 2 locations in Taiwan, 9 lines had average yields that were more than double that of the local check TK 3 (Table 5).

Table 5. Yields and other horticultural traits of the 9 best processing tomato breeding lines planted at two locations in the fall; 1976, AVRDC.

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield average	Marketable yield Y. Mei[a]	Marketable yield AVRDC[b]	Fruit size[c]	Days to flower[c]
		(t/ha)	(t/ha)	(t/ha)	(g)	(no.)
32d-0-1-10-0	VC 9-1-2-3/Venus	66	50	83	67	31
33d-0-2-1-0	VC 9-1-2-3/Saturn	63	56	71	45	27
32d-0-1-25-0	VC 9-1-2-3/Venus	60	51	70	54	33
32d-0-1-13-0	VC 9-1-2-3/Venus	57	50	64	63	31
32d-0-1-7-0	VC 9-1-2-3/Venus	56	42	69	63	28
32d-0-1-2-0	VC 9-1-2-3/Venus	56	46	65	66	29
122-0-4-1-0	ahTM2a/VC 11-1	56	46	65	41	26
179-0-1-4-0	VC 11-1/Tamu Chico III	55	45	66	30	26
32d-0-1-11-0	VC 9-1-2-3/Venus	54	43	66	62	30
(123)	(TK 3)	25	24	27	48	34
LSD 5%		13	14	13	13	5

[a]Planted at Yeong Mei in southern Taiwan Nov 16 (1975). [b]Planted at AVRDC Nov 3. [c]Data from AVRDC planting.

Monthly plantings of both fresh market and processing tomato selections showed a clear reduction in yields as night temperatures and rainfall increased in July (Table 6). However, some of our selections in the April planting produced respectable yields at a time when tomatoes were becoming scarce in the local markets.

Seed yield and quality of 9 breeding lines were superior to Roma in a test comparing various horticultural traits of this popular cultivar with 13 AVRDC lines. Eight of the lines also produced higher marketable yields and matured earlier than Roma (Table 7).

We initiated a series of experiments to study the genetic stability of heat tolerance in tomato. Our observations suggest that the genes controlling heat tolerance are easily influenced by environmental factors and, therefore, our heat-tolerant selections should be tested in as many locations and seasons as possible to define the exact nature of their heat tolerance. The results of another AVRDC experiment confirmed that both heat and cold tolerance might be controlled by the same gene(s).

Table 6. Yield of the best entries in monthly plantings of fresh market and processing tomato breeding lines; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Date of trials			Average yield
		Feb-May	Mar-Jun	Apr-Jul	
Fresh market tomato:		(t/ha)			
143-0-4B-1-0	VC 48-1/Tamu Chico III	20	26	12	19
143-0-6-9-0	VC 48-1/Tamu Chico III	17	24	9	17
9d-0-3-6-0	VC 11-1-2-1B/Saturn	15	19	11	15
11d-0-2-2-0	VC 9-1-2-9B/Venus	17	18	11	15
(388)	(Green Skin)	12	7	7	9
LSD 5%		6	6	4	
Processing tomato					
143-0-4B-1-0	VC 48-1/Tamu Chico III	24	26	12	21
143-0-10-3-0	VC 48-1/Tamu Chico III	23	21	15	20
7-0-5-1-0	VC 11-1-2-1B/Florida MH-1	23	24	11	19
11d-0-1-2-0	VC 9-1-2-9B/Venus	17	20	13	17
(123)	(TK 3)	18	21	9	16
LSD 5%		7	ns	3	

[a]All values are means of 3 replications.

Research workers in the Philippines selected from AVRDC breeding materials several lines that produced good yields when partially shaded or grown in an untilled paddy field following rice (Table 8). These attributes are particularly useful in developing tomato materials for inclusion in intensive cropping systems.

We were also encouraged by a report from researchers at the Philippine Sugar Research Institute (PHILSUGIN) that 8 of our breeding lines did very well during the hot, wet season when intercropped with sugar cane (Table 9). Cane and sugar yields were generally not affected by the intercrop except in one case which was due to a low percentage of cane replants and the harvest of the cane at 10 months (before full maturity).

Table 7. Marketable yield and other horticultural traits of 8 processing tomato selections compared to that of the commercial cultivar Roma; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield	Fruit size	First flower	Total solid	pH	Citric acid
		(t/ha)	(g)	(days)	(^{o}Brix)		(mg/100g)
123-1	Selection from TK 3	54	25	26	5.1	4.2	387
11d-0-1-2-0	VC 9-1-2-9B/Venus	52	42	24	5.9	4.2	418
122-0-5-3-0	ahTM2a/VC 11-1	51	26	22	6.2	4.5	287
124-1	Selection from TK 70	51	32	12	6.2	4.2	405
32d-0-19-0	VC 9-1-2-3/Venus	48	42	15	6.2	4.4	320
8d-0-7-1-0	VC 11-1-2-1B/Venus	48	30	26	5.3	4.3	350
143-0-4B-1-0	VC 48-1/Tamu Chico III	47	20	22	5.5	4.2	424
32d-0-1-25-0	VC 9-1-2-3/Venus	46	36	14	6.0	4.4	337
(115)	(Roma)	32	37	46	5.8	4.4	331
LSD 5%		13		7	0.1	0.1	101

[a]Planted Nov (1975). All values are means of 3 replications.

Table 8. Fruit size and yield of tomato breeding lines and cultivars when direct seeded in uncultivated paddy soil; 1976, IPB, Philippines.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Fruit size	Marketable yield
		(g)	t/ha
554 F_4-62	VC 8-1-2-1/Venus//Kewalo	65	26
554 F_4-34	VC 8-1-2-1/Venus//Kewalo	44	28
554 F_4-30	VC 8-1-2-1/Venus//Kewalo	41	28
32d-0-1-13-1	VC 9-1-2-3/Venus	37	28
(9)	(VC 9-1)	34	26
(21)	(VC 11-1)	31	28
30-4-1-1	VC 9-1-1/Saturn	29	26
(232)	(Nagcarlan)	14	29

[a]Data supplied by Dr. L. T. Empig, Institute of Plant Breeding (IPB), Los Banos, Philippines. Tomato seed dibbled near a rice stubble.

Plain straw mulch proved more economical and equally as effective as this table support system in four out of five tests during the 1976 wet season.

Table 9. Marketable yields of tomato, cane, and sugar for two tomato/sugarcane intercropping experiments; 1975-76, PHILSUGIN, Philippines.[a]

Trial I				Trial II			
AVRDC selection no.	Tomato yield	Cane yield	Sugar yield	AVRDC selection no.	Tomato yield	Cane yield	Sugar yield
	t/ha	TC/ha	PS/ha		t/ha	TC/ha	PS/ha
435	11	78	160	434	11	57	143
432	7	41	85[b]	764	10	64	132
547	6	50	103	433	9	73	152
431	5	54	113	502	7	57	120
Cane alone	0	60	125	Cane alone	0	61	126
LSD 5%	3	14	28		4	ns	ns

[a]Sugarcane planted May 12, 1975 (onset of rainy season) at 30,000 cuttings/ha. 1-month tomato seedlings were immediately transplanted between 1-m rows of cane. Tomato harvesting began 65 days after transplanting and lasted for 23 days. Cane was harvested Apr 1, 1976.
[b]The lower cane yield resulted from early harvest.

Soybean

Soybean Research Objectives

*Higher yielding, early maturing cultivars with insensitivity to photoperiod

*Varietal resistance to soybean rust, bacterial pustule, downy mildew, and soybean mosaic virus

*Varietal tolerance to beanfly and other insect pests

*Economic management alternatives for tropical farmers with limited resources

At a glance: Soybean yields and population growth of selected tropical and temperate countries; 1965 to 1974.[a]

Country	Ave. yields 1965	Ave. yields 1974	Change in yield	Population growth; 1965 to 1974
	(t/ha)	(t/ha)	(%)	(%)
China, mainland	0.8	0.8	0	17
Indonesia	0.7	0.8	14	30
Nigeria	0.3	0.4	33	26
Philippines	0.8	0.8	0	35
Taiwan, R.O.C.[b]	1.2	1.5	25	25
Thailand	1.0	1.1	10	34
Brazil	1.2	1.6	33	29
U. S. A.	1.6	1.6	0	9

[a]Data from FAO Production Yearbooks, 1970 through 1974, except for Taiwan. [b]Taiwan Agricultural Yearbook, 1975 edition.

The *Glycine* germplasm collection was increased with the addition of 349 entries from 10 countries. A computer sorting of our accession list eliminated 862 duplicates for a total of 8580 different entries at the end of 1976. We distributed seed packets of 3783 cultivars and 1840 breeding lines to 60 researchers in 24 countries.

Forty of our best selections were tested for seasonal stability in advanced yield trials. The highest yields were obtained in the spring trial (Fig. 1). We also screened 352, 403, and 456 entries for yield and early maturity in spring, summer, and fall preliminary trials. The best 6 entries for each trial are listed in Table 1.

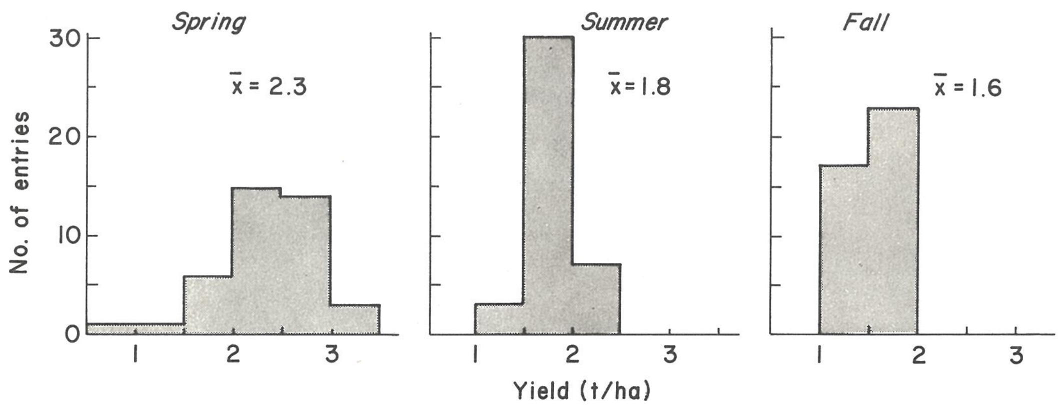


Fig. 1. Distribution by yield of the same 40 soybean cultivars in spring, summer, and fall advanced yield trials; 1976, AVRDC.

By decapitating the meristem when the unifoliate leaf was fully open, we were able to stimulate the growth of 2 axillary buds at the unifoliate leaf node. To test the flowering response of cultivars, each of the 2 branches was exposed to different photoperiods. We used the technique to confirm the photoperiod insensitivity of 45 cultivars and to study the inheritance of photoperiod response. Photoperiod insensitivity apparently is controlled by a single recessive gene as we were able to combine longer days to flowering with photoperiod insensitivity (Table 2). Photoperiod was also found to influence further plant growth and development as well as days to flowering. Several cultivars were completely insensitive to photoperiod at most stages of growth.

The small to medium sized seeds of Acc. 2120 and Shih-Shih were nearly doubled by deflowering and de-podding the plants, indicating that the genetic potential for larger seed size exist for these cultivars.

We continued our efforts to identify and confirm sources of resistance to soybean rust caused by *Phakopsora pachyrhizi*. Two selections, 60040-1 and 30066-2-11, and 3 cultivars, PI 230970 (green seed), PI 230970 (black seed), and PI 230971, were determined to be moderately resistant to rust in a series of field and laboratory tests (Table 3).

Two cultivars, PI 176486 and PI 157409, were consistently resistant to sclerotial blight (*Sclerotium rolfsii*) in 2 successive screenings of 136 entries. Cultivars PI 371611, PI 189402, and PI 374157 were determined to be resistant to bacterial pustule (*Xanthomonas*

Table 1. The best entries in spring, summer, and fall preliminary yield trials for both yield and early maturity; 1976, AVRDC.

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Yield[a]	Days to maturity	Plant ht at maturity
		(t/ha)	(no.)	(cm)
Spring trial[b]				
30037-2-10	Kairyoushirome/Tainung 3	4.4	93	43
30229-2	Shih-Shih/SRF 400	4.1	98	51
30231-2-1	PI 153212/KS 482	4.1	105	53
30257-1-7	Forrest/Shih-Shih	4.0	104	53
30047-2-11	Higo Daizu/KS 528	3.9	101	59
40178-1-6RT	PI 180520/CH 1	3.3	88	57
(2043)	(Kaohsiung 3)	2.6	108	55
Mean (352 entries)		2.1	102	57
LSD 5%		1.0	8	16
Summer trial[c]				
30203-52	Lee/P 156	3.6	96	52
40142-0-103	CH 3/PI 297550	2.8	85	77
40249-0-6	PI 78242/CH 1	2.8	94	69
30293-7-7	CH 1/Anoka	2.8	97	73
30293-6-11	CH 1/Anoka	2.7	93	70
40085-2-7	PI 195529/CH 3	2.6	85	83
(2043)	(Kaohsiung 3)	2.0	95	58
Mean (403 entries)		1.9	93	70
LSD 5%		0.7	6	18
Fall trial[d]				
30187-10-9	CH 2/KS 528	2.1	99	57
30120-2-10	KS 482/Lee	2.0	102	61
30106-2-94	TN 4/Bansei Kuro Daizu	2.0	91	54
30120-42-6	KS 482/Lee	2.0	98	50
30187-10-10	CH 2/KS 528	2.0	99	53
40058-2-6	TK 5/Wakashima 2	1.9	88	57
(38)	(Shih-Shih)	1.3	76	44
Mean (456 entries)		1.3	93	53
LSD 5%		0.5	8	11

[a]Actual yields unadjusted for stand from 10 m^2 plots with 2 replications. [b]Planted Feb 17; mean no. of plants/ha harvested = 172,000. [c]Planted Jul 20; mean no. of plants/ha harvested = 232,000. [d]Planted Sep 10; mean no. of plants/ha harvested = 218,000.

Table 2. Recombination of photoperiod insensitivity with longer days to flowering in Cross 50016 between the photoperiod insensitive (PI) cultivar, PI 194647, and the sensitive (PS) line, Acc. 2120; 1976, AVRDC.

Source	Photoperiod treatment 10 hr	Photoperiod treatment 16 hr	Photoperiod response
	(days to 1st flower)		
P_1 (PI 194647)	29	29	insensitive
P_2 (Acc. 2120)	54	a/	sensitive
F_1 (PI 194647/Acc. 2120)	40	75	sensitive
F_2 50106-8	42	42	insensitive
F_2 50106-13	33	33	"
F_2 50106-47	36	36	"
F_2 50106-91	47	47	"
F_2 50106-120	43	43	"
F_2 50106-130	47	47	"

[a]Did not flower by 150 days at which time the experiment was terminated.

Table 3. List of soybean cultivars having moderate resistance to soybean rust; 1976, AVRDC.

AVRDC acc. (or selection) no.	Cultivar name (or pedigree)	Soybean rust rating[a]	Origin
8586	PI 230970 (yellow)	323	Japan
8586	PI 230970 (black)	323	Japan
8587	PI 230971	232	Japan
(30066-2-11)	(HS 3/Shin 2)	333	AVRDC
(60040-1)	(PI 230970/Acc. 2120)	333	AVRDC

[a]Rust rating notation adopted by International Working Group on Soybean Rust (AVRDC Soybean Report for 1975). '323' indicates that the upper leaves were infected with a few sporulating rust pustules; '333' indicated an increase in no. of pustules over 323.

phaseoli var. *sojense*). More than 700 cultivars were artificially inoculated with soybean mosaic virus and 72 entries remained symptomless in a preliminary field screening.

A total of 1060 cultivars were screened for relative resistance to beanfly (*Melanagromyza* sp.) infestation in a series of 9 trials. Seven cultivars (A 2-5440, PI 68552, Lindarin, PI 70561, PI 90570, Granger 387, and PI 79797) had zero infestation levels and another 116 entries had relatively low infestation rates. Three cultivars were determined to have relative resistance to spider mites (*Tetranychus truncatus*).

The population dynamics of 4 insect pests (beanfly; scarab, *Anomala cupripes;* pod borer, *Etiella zinckenella;* and stinkbug, *Nezara viridula*) were surveyed throughout the year using a black-light trap. The fall crops were attacked by all four (Fig 2). Populations of spider mites and soybean aphids (*Aphis glycines*) also increased in the fall.

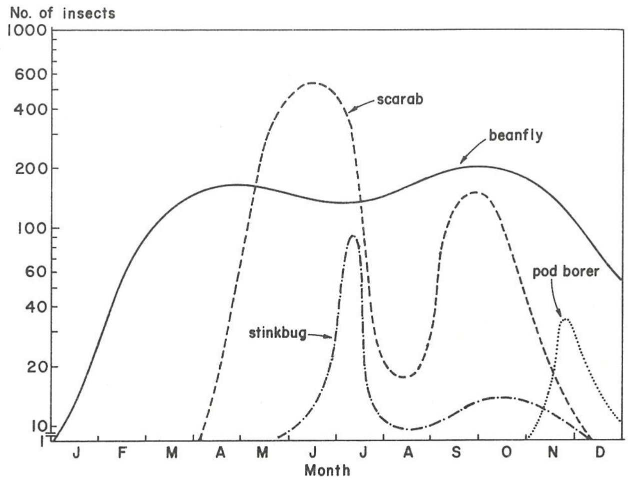


Fig. 2. Seasonal populations of 4 insect pests of soybean; 1976, AVRDC.

An experiment conducted in the greenhouse determined that severe aphid infestation significantly reduced plant height, pod number, and yield.

Four insecticides at different rates provided effective control of beanfly in a fall screening (Table 4).

Table 4. Comparison of insecticides at various rates for control of beanfly in soybean; 1976, AVRDC.[a]

Insecticide treatment[b]	Rate	No. of beanflies	Damage rate (%)	Yield
	(kg a.i./ha)	(per 30-plant sample)		(t/ha)
Terbufos 10%G	2	22a	62a	1.5a
Disulfoton 5%G	2	26ab	78ab	1.5a
Terbufos 10%G	1.5	20a	62a	1.4a
Terbufos 10%G	1	22a	68a	1.4a
Mephosfolan 3%G	1.2	16a	53a	1.4ab
Mephosfolan 3%G	0.9	22a	67a	1.4ab
Geophos 5%G	1	24a	79ab	1.4ab
Geophos 5%G	0.75	28ab	84 bc	1.3ab
Geophos 5%G	0.50	35 b	88 bc	1.2 bc
Control		49 c	93 c	1.0 c

[a]Cultivar TK 5 was sown Sep 14; sampled Oct 18; 10 m^2 plots with 4 replications; harvested Dec 10; means followed by same letter are not signigicantly different at 5% level. [b]Insecticides top banded at planting.

We studied varietal variations in nitrate reductase activity (NRA) and the relationship between NRA and yield in order to develop selection criteria for high yield. The youngest trifoliate leaf had the maximum NRA when fully open and the peak NRA occurred between 10:00 am and 12:00 noon. Four types of NRA patterns were identified (Fig 3). The selection 30217 -1-28 (KS 535/KS 482) had the highest NRA levels at pod filling, indicating a good supply of nitrogen was available at that critical growth stage. Total NRA before flowering (26 days after planting) was significantly correlated with total nitrogen and total dry weight at 41 days (Table 5).

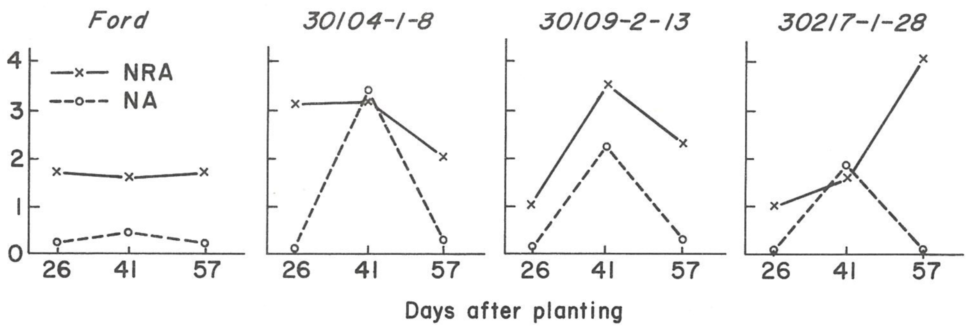


Fig. 3. Total nitrate reductase activity (NRA) [(μ moles NO_2/plant per hr) x 10] and nitrogenase activity (NA) [μ moles $C_2H_2 \rightarrow C_2H_4$/plant per hr) x 3] at various growth stages for a local soybean cultivar and 3 AVRDC breeding lines; 1976, AVRDC.

Table 5. Correlation coefficients between total nitrate reductase activity (NRA) and total N and total dry weight; 1976, AVRDC.

Item	Total NRA (Before flowering stage)[a]
Total N at 26 days after planting (DAP)	r_1= 0.7589* r_2= 0.6331*
Total N at 41 DAP	r_1= 0.9619** r_2= 0.8028**
Total N accumulated from 26 to 41 DAP	r_1= 0.9332** r_2= 0.7818**
Total dry wt at 26 DAP	r_1= 0.6730* r_2= 0.3554 ns
Total dry wt at 41 DAP	r_1= 0.9539** r_2= 0.8317**
Total dry wt accumulated from 26 to 41 DAP	r_1= 0.9277** r_2= 0.8325**

[a]r_1(N=8); r_2(N=13); 26 days after planting.

Heavy rain at planting generally results in poor stands and increased production costs as the crop often has to be replanted (AVRDC Soybean Report '75). When we flooded the field for 4 to 8 hours immediately after planting, the stand establishment was only 58% (Table 6). By treating the seed with Captan fungicide, we were able to improve the stand to a point where replanting was not necessary (Table 7). These results should be useful to farmers in southern Taiwan and northern Thailand who sow soybean in untilled rice stubble.

Table 6. Effect of excessive soil moisture soon after sowing on soybean plant stand and seedling fresh weight in rice-stubble culture; 1976, AVRDC.[a]

Days after sowing when flooded	Plant stand[b]				Seedling fresh wt			
	not flooded	flooded 4 hr	flooded 8 hr	mean	not flooded	flooded 4 hr	flooded 8 hr	mean
(no.)	(%)				(g/plant)			
0	84	51	38	58	5.8	4.6	4.4	4.9
2	94	91	86	91	5.8	5.9	6.2	6.0
4	94	90	84	89	6.0	5.8	6.2	6.0
6	90	88	90	90	6.1	5.5	6.1	5.9
8	91	88	92	90	5.8	5.5	5.8	5.7
Mean	90	82	78		5.9	5.5	5.8	

LSD 5%: between 2 flooding duration means = 5% stand; ns seedling wt

between 2 time period means = 10% stand; 0.4g seedling wt

between 2 time period means at same level of flooding duration = 17% stand; 0.7g seedling wt

between 2 flooding duration means at same level of time period = 13% stand; 0.7g seedling wt

[a]Cultivar Shih-Shih dibbled near rice stubble Oct 1 and data recorded Oct 18; germination rate in Petri dish was 95%. [b]Plant stand was calculated by dividing mean no. of plants by no. of seeds sown (32 seeds/m^2).

Table 7. Effect of fungicide seed treatment on soybean plant stand and seedling fresh weight when grown under rice stubble culture conditions with excessive soil moisture applied at various times after sowing; 1976, AVRDC.[a]

Days after sowing when flooded	Plant stand[b]			Seedling fresh wt		
	not treated	treated with fungicide[c]	mean	not treated	treated with fungicide[c]	mean
(no.)	(%)			(g/plant)		
Control	68	77	72	2.7	2.5	2.6
0	40	65	53	2.2	2.3	2.2
2	64	72	68	2.4	2.2	2.3
4	59	77	68	2.4	2.5	2.4
6	69	82	75	2.5	2.6	2.6
mean	60	74		2.4	2.4	

LSD 5%: between 2 fungicide means = 7% stand; ns seedling wt

between 2 time period means = 9% stand; 0.2g seedling wt

between 2 time period means at same fungicide level = 13% stand; 0.3g seedling wt

between 2 fungicide means at same time period = 14% stand; 0.4g seedling wt

[a]Cultivar Shih-Shih dibbled near rice stubble Oct 20 and data was recorded Nov 9; flooding duration was 6 hr; germination rate in Petri dish was 95%. [b]Plant stand was calculated by dividing mean no. of plants by no. of seeds sown (32 seeds/m^2). [c]Fungicide was Captan.

Burning rice straw in the field after sowing soybean is a common practice of farmers using no-tillage, rice stubble methods. This practice significantly controlled both broadleaf and grassy weeds in an AVRDC experiment (Table 8).

Table 8. Effect of burned rice straw and rice straw mulch on soybean yield and weed growth under rice stubble conditions.[a]

Rice straw treatment	Amount	Yield	Weed weight[c]		
			broadleaf	grasses	total
	(t/ha)	(t/ha)	-----[fresh wt (g/m^2) of weeds]-----		
Burned	4	1.7a	7a	222a	229a
"	6	1.8a	4a	243a	247a
"	8	1.8a	6a	133a	140a
Mulch	2	1.0 b	71 b	689 b	760 b
"	4	1.2 b	119 b	611 b	730 b
"	6	1.3 b	80 b	548 b	628 b
Control		1.2 b	98 b	574 b	672 b

[a]Cultivar Shih-Shih was dibbled near rice stubble Sep 14 and harvested Dec 13; weeds were harvested and weighed Dec 9. [b]Preceding rice crop produced 4000 kg/ha of rice straw. [c]Predominant weeds included: *Echinochloa colonum, E. crusgalli,* and *Aternanthera sessilis.* Minor weeds were: *Cyperus* sp., *Ammania bacoifera, Ludwigia octovalis,* and *Chenopodium album.*

A combination of closer spacing, vigorous early growth, and the preemergence application of alachlor (1.5 kg a.i./ha) effectively controlled weeds during the fall crop at AVRDC. When soybean was grown during the wet summer season or at wide spacings, the post emergence (30 days after emergence) spraying of paraquat (0.75 a.i./ha) was required in combination with the preemergence spraying of alachlor for effective weed control.

Through a series of soil fertility experiments supported by the International Minerals and Chemicals Co., we continued to study the response of soybean to applications of nitrogen on our calcareous soils at AVRDC. By comparing AVRDC's soil with 3 other soil types (Table 9) in a greenhouse experiment, we noted that soybean grown in the two soil types lowest in organic matter had the greatest response in yield to inoculation (Fig. 4). Furthermore, whereas there was at least a slight increase in soybean yield to the N applications for each soil type, only in the AVRDC calcareous soils did the increased rates of N also increase nodule dry weight (Fig. 5). Therefore, we have tentatively concluded (i) that *Rhizobium* inoculation should increase soybean yields on soils having low organic matter and (ii) that soybean yields on calcareous soils can be significantly improved by management practices that include the use of inoculants and N fertilizer.

Table 9. Chemical characters of 4 soil types used to test response of soybean to applications of *Rhizobium* inoculation and nitrogen application; 1976, AVRDC.

Soil type (location)	pH	Calcium (ppm)	Organic matter (%)
Calcareous alluvial (AVRDC)	8	2240	1.5
Red latosolic, oxisol (Taichung)	4.5	125	0.9
Slate alluvial, entisol (Shinshē)	6.5	600	2.0
Black, Mollisols (Taitung)	6.0	325	3.5

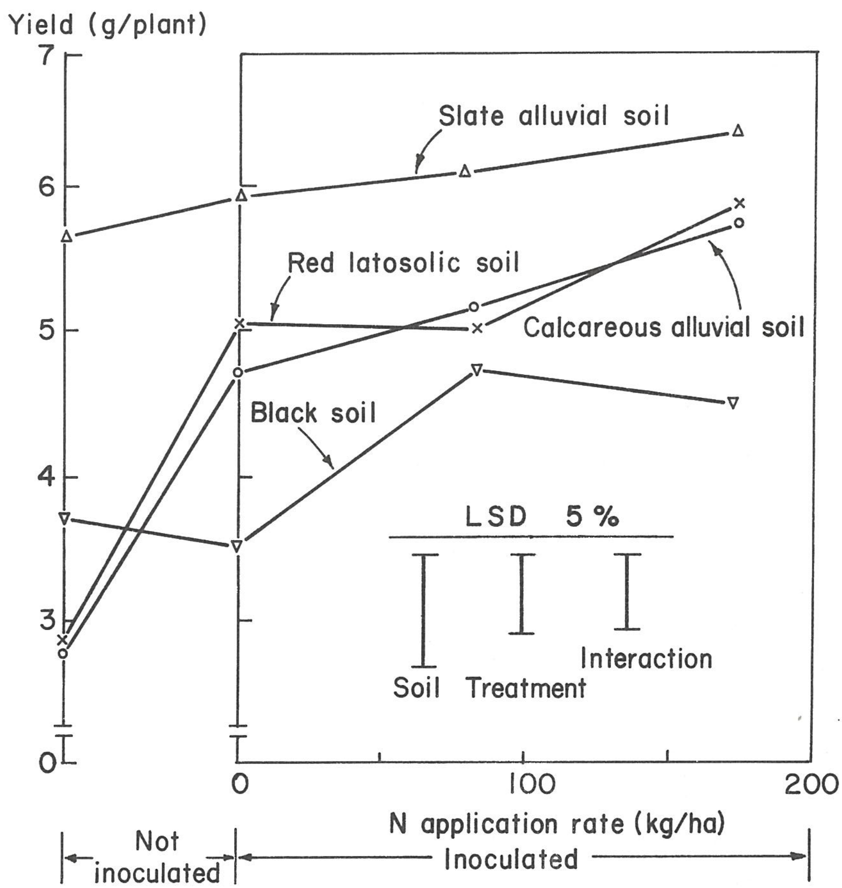


Fig. 4. Effect of *Rhizobium* inoculation and N application on yield per plant of the soybean cultivar Shih-Shih grown on 4 different soil types (see Table 9); 1976, AVRDC.

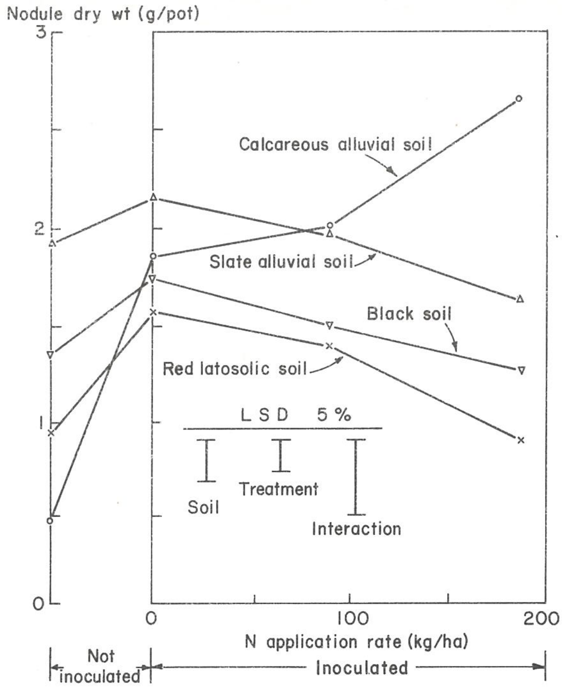


Fig. 5. Effect of *Rhizobium* inoculation and N application on nodule dry weight on soybean plants grown in 4 different soil types (see Table 9); 1976, AVRDC.

Individual uredium containing uredospores and paraphyses of *Phakopsora pachyrhizi* of soybean rust under scanning electron microscope (x 1,500, photo by C.Y. Yang).

A survey of 21 soybean cultivars using acetylene reduction assays demonstrated that substantial varietal differences exist in soybean's ability to fix atmospheric nitrogen. Thus, we will use acetylene reduction to screen for germplasm with high N-fixation capacity.

Cooperators in Argentina, Indonesia, India, the Philippines, Korea, Thailand, and Puerto Rico (INTSOY) conducted a number of trials using AVRDC germplasm and breeding lines. Our selection 30211-2-68 F_5 (TK 5/CH 2) produced yields of 5.9 and 3.2 t/ha in trials conducted at Mindanao State University and AVRDC's Philippine Outreach Program (Los Banos), respectively, in the Philippines. The high yielding cultivar Clark 63 yielded 2.8 and 2.3 t/ha in the same trials. Several of our lines also performed well in a trial planted in Chiang Mai, Thailand (Table 10).

Table 10. The best 5 AVRDC selections compared to check cultivars in an advanced yield trial at Mae Jo, Chiang Mai; 1976, Thailand.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Yield	Days to maturity
		(t/ha)	(no.)
30153-1-102	66-D-20/Jupiter	3.0	99
30155-1	66-G-3// Jupiter/F 65-170	2.8	108
30271-6-73	KS 535/SL-6	2.8	98
30106-1-5	Tainung 4/Bansei Kyro Daizu	2.6	100
30120-2-162	KS 482/Lee	2.6	112
(2572)	(SJ 1)	2.2	104
(86)	(Clark 63)	1.8	99
(2573)	(SJ 2)	1.8	108

[a]Data supplied by Dr. Arwooth Nalampang of Chiang Mai, the Dept. of Agriculture, Bangkok, Thailand; 83 AVRDC selections were screened; Planted Jan 19; 8 m^2 plots; 2 replications.

Sweet Potato

SWEET POTATO RESEARCH OBJECTIVES

* Higher productivity of roots with more available protein and β-carotene
* Varietal resistance to sweet potato weevil and the witches' broom disease
* Development of management practices to optimize farmers' returns.
* Better consumer acceptability of more nutritious roots and tips

At a glance: Sweet potato yields and population growth of selected countries; 1965 to 1974.[a]

Country	Ave. yield 1965	Ave. yield 1974	Change in yield	Population increase from 1965 to 1974
	---(t/ha)----		(%)	(%)
Bangladesh	9	10	11	37
Cameroon	4	4	0	21
China, mainland	8	9	12	17
Ethiopia	4	4	0	21
Haiti	5	5	0	22
India	7	8	14	21
Indonesia	6	6	0	30
Papua New Guinea	6	4	-33	22
Philippines	5	5	0	35
Sudan	3	4	33	28
Taiwan, R.O.C.[b]	13	15	15	25
Thailand	7	9	29	34
U. S. A.	10	13	30	9

[a]Data from FAO Production Yearbooks, 1970 through 1974, except for Taiwan. [b]Taiwan Agricultural Yearbook, 1975 edition.

We studied the influence of climate, water availability, soil type, fertilizer application, and cropping pattern on sweet potato yield in farmers' fields. In a survey of 317 farmers in 6 districts of Taiwan, we learned that the fall sweet potato crop had the highest yields, especially when irrigation water was available (Table 1). Loam and sandy loam soils were considered to be the most suitable by the farmers. Our survey results indicated that there was an excessive use of chemical fertilizers, particularly in the fall relay crop.

Table 1. Average sweet potato yields by season (or cropping method) on irrigated and rainfed farms; 1976, Taiwan.

Month(s) planted	Cropping method	Irrigated land		Rainfed land		Average	Total
		ave. yield	farmers	ave. yield	farmers	yield	farmers
		(t/ha)	(no.)	(t/ha)	(no.)	(t/ha)	(no.)
Oct	mono	26	92	16	18	24	110
Feb-Mar	mono	15	18	13	26	14	44
Jul-Aug	mono	13	27	9	30	11	57
Oct	relay	12	32			12	32
Average (total)		20	(169)	12	(74)	18	(243)

The major conclusions of our survey in Taiwan are:

1) Agronomic yield potential by season was positively correlated with levels of both overall investment and net profit;
2) Sweet potato was a low capital, labor-intensive crop, especially in the summer season when yield potential is low;
3) Low-input technology could provide good economic returns to farmers with capital constraints but abundant labor;
4) The use of feed concentrates and the presence of local starch factories were the major stimuli to sweet potato maketing;
5) Farmers who produce sweet potato raised more hogs;
6) Farmers who had stopped producing sweet potato were more conscious of profit than current producers;
7) Current sweet potato producers faced more natural constraints to agricultural production than those who did not produce sweet potato; and
8) Lack of irrigation was a major reason for growing sweet potato.

We continued to test our sweet potato germplasm and breeding lines under minimum input conditions, which involved only minimal land preparation and the bedding of the cuttings. This year's trial of breeding lines had substantially lower yields than a similar 1975 trial (Table 2) due to colder weather and greater weed competition. Two cultivars (PI 344123 and PI 344129) produced 13 to 14 t/ha despite severe competition from *Chenopodium album* for nutrients, water, and light in a companion trial of cultivars.

Table 2. List of the highest yielding table sweet potato breeding lines in two dry season minimum input trials; 1974-76, AVRDC.

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield 1975[a]	Marketable yield 1976[b]	Flesh color of root	Flowering habit[c]
		-----(t/ha)----			
278-1	Tainung 27/HDK 8	20	8	yellow	irregular
277-1	Red Tuber Tail/OK 6-3-118	18	5	yellow	good
0122-2	B 6708 (op)[d]	16	8	orange	good
272-8	Red Tuber Tail/Allgood	15	2	yellow	irregular
015-10	HDK 6 (op)	15	2	orange	irregular
010-2	HDK 8 (op)	14	4	yellow	irregular
272-2	Red Tuber Tail/Allgood	13	8	yellow	good
(171)	(Tainung 63)	4	2	orange	irregular

[a]Planted Nov 15 (1974) and harvested Apr 19 (1975) (155 days); based on yields from 10 hills.
[b]Planted Nov 19 (1975) and harvested Apr 21 (153 days); based on yields from 20 hills.
[c]Good=flowered readily under AVRDC conditions; irregular = will not flower without stimulation under AVRDC conditions. [d](op)=open pollinated.

Note that we have only mentioned 'table' types, i.e., having orange or yellow fleshed roots because of our breeding objectives. However, many of the white-fleshed, starchy lines and cultivars out-performed the table types under minimum input conditions and, therefore, will also be used in breeding for high yield under adverse conditions.

A comprehensive crop management study determined that a certain level of weed control was essential for high sweet potato root and tip yields under AVRDC conditions (Table 3). Fertilizer application, land preparation, irrigation, and vine turning had little or no influence on yields.

Table 3. Effect of weed control and other management practices on the yields of sweet potato roots and tips and weeds compared for two planting methods, rice stubble without irrigation (min) and bed culture with irrigation (max); 1976, AVRDC.[a]

Management combinations			Mean yields					
weed control	fertilizer side dressed	vine turning	roots min	roots max	tips min	tips max	weeds[b] min	weeds[b] max
			------------(kg/10 m²)---------------					
No	No	Yes	3	2	3	4	8	6
No	Yes	Yes	4	5	4	5	10	10
No	Yes	No	4	3	4	5	8	8
Yes	No	Yes	14	19	20	19	3	3
Yes	Yes	Yes	19	21	23	29	<1	<1
Yes	Yes	No	19	21	40	27	<1	4
LSD 5% between planting methods			8		17		8	

[a]Cultivar Tainan 14 was planted Dec 5 (1975) and harvested May 24 (171 days); values are means of 3 replications. [b]*Chenopodium album* predominated.

In a preliminary yield trial conducted during the hot, wet season, we applied a minimal amount of fertilizer (30, 60, 90 kg NPK/ha) and 5 of our breeding lines produced yields significantly higher than the local cultivar Tainung 63 (Table 4).

Table 4. Performance of table sweet potato breeding lines in a wet season preliminary yield trial; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield	Transformed weevil rating[b]	Transformed rat damage[b]
		(t/ha)		
0122-2	B 6708 (op)	26	1.8	4.6
209-2	B 6708/OK-9-3	24	2.0	2.4
272-9	Red Tuber Tail/Allgood	21	1.5	1.5
016-2	HDK 12 (op)	20	1.7	3.8
057-4	Tainung 57 (op)	19	1.6	1.8
(171)	(Tainung 63)	14	1.8	3.2
LSD 5%		5	0.3	1.5

[a]Planted Jul 28 and harvested Dec 6 (130 days). [b]Data were transformed using $\sqrt{x + 0.5}$ before analysis of variance.

In the past we have lost several of our experimental plantings due to repeated flooding during the summer. This summer we screened 124 table and 203 industrial sweet potato cultivars for their ability to form large roots during the wet season. Only 4 table cultivars produced higher marketable yields than the local cultivar Tainung 57 (Table 5).

Table 5. Comparison of 4 table sweet potato cultivars by yield and pest damage with a local cultivar (Tainung 57) in a wet season observational trial; 1976, AVRDC.[a]

AVRDC acc. no.	Cultivar name	Origin	Yield: marketable	Yield: total	Weevil damage score[b]
			(t/ha)		
36	Copper Skin Goldrush	U.S.A.	9	16	2
176	Dwarf Sweet Potato	Philippines	8	14	2
56	PI 344127	U.S.A.	7	10	2
3	Centennial	U.S.A.	6	8	2
57	Tainung 57	Taiwan	4	8	2

[a]124 cultivars were planted Mar 31 and harvested Aug (123 days); 2 replications. [b]Weevil damage scored from 1 to 5 with 5 indicating severe damage.

We tested some of our better breeding lines during both the summer and winter seasons. Of the table types tested, Selection 35-2 performed very well in both plantings (Table 6).

In a yield trial for sweet potato tips, we were pleased to find that 3 of the best tip producers also produced respectable root yields of 15 to 16 t/ha (Table 7). In an organoleptic test, these 3 cultivars (PI 344120, PI 344138, PI 318856) also received the best acceptability ratings.

Table 6. Yields and daily production rates of table sweet potato selections in summer and winter trials; 1975-76, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield		Daily production	
		summer[b]	winter[c]	summer	winter
		-------(t/ha)------		-------(kg/ha)-----	
209-3	B 6708/OK 9-3	33	5	28	3
35-1	HDK 6/B 6708	24	6	22	4
35-2	HDK 6/B 6708	19	15	17	9
272-6	Red Tuber Tail/Allgood	16	4	15	2
259-4	HM 16/B 6733	13	6	11	3
200-3	B 6708/Centennial	13	3	11	2
294-1	Polycross 2	12	7	10	4
(171)	(Tainung 63)	19	3	16	2
(30)	(Centennial)	14	6	12	3

[a]Data are means of 3 replications. [b]Planted Jul 28 and harvested either Nov 15 (110 days) or Nov 25 (120 days). [c]Planted Oct 28 (1975) and harvested either Apr 6 (160 days) or Apr 21 (175 days).

Table 7. Tip yield, tip acceptability scores, and root yield of 10 sweet potato cultivars; 1976, AVRDC.[a]

AVRDC acc. no.	Cultivar name	Tip yield[b]			Acceptability of tips[d]	Marketable root yield[e]	Flesh color of root
		wt	no.	T[c]			
		(t/ha)	(1000/ha)		(7 to 1)	(t/ha)	
212	Dilaw	16	1415	38	4.3	2	yellow
229	Kinangkong	14	3525	59	4.7	1	white
119	PI 344138	14	1863	43	5.2	15	yellow
112	PI 344120	14	2082	46	5.5	15	yellow
8	Daja 380	13	744	27	4.6	10	yellow
104	PI 318856	12	1250	35	5.0	16	orange
33	Earlyport	11	968	31	4.7	9	orange
1	BNAS-white[f]	11	1233	36	4.9	12	yellow
127	HM 16	11	1307	37	4.9	3	orange
31	Rose Centennial	10	613	25	5.0	6	orange
	LSD 5%	3		5	ns	3	

[a]Planted Jul 28; data are means of 3 replications. [b]Harvest 6 times at 14-day intervals from Sep 6 to Nov 23. [c]Transformation using square roots of the no. of tips/ha. [d]Means of scores of 21 taste panel members with 2 replications; 7 (highly acceptable) to 1 (highly unacceptable). [e]Harvested Dec 6 (130 days). [f]Check cultivar.

Five of our better sweet potato selections compared favorably with local cultivars in eating quality (of their roots) (Table 8). Statistical analysis of this organoleptic test indicated a strong national bias. Therefore, our selections will be tested in the future by country (or location) specific taste panels.

Table 8. Average eating quality scores of 5 sweet potato selections and 2 cultivars in sweet potato root organoleptic test; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Eating quality characteristic[b]				
		acceptability	flavor	dryness	stickiness	color
		(7 to 1)				
(171)	(Tainung 63)	5.6	5.4	5.0	5.1	5.5
031-3	Rose Centennial (op)	5.4	5.6	5.2	5.3	5.7
35-2	HDK 6/B 6708	5.2	5.3	5.1	5.2	5.2
35-1	HDK 6/B 6708	4.8	4.8	4.6	4.6	5.1
272-6	Red Tuber Tail/Allgood	4.7	4.8	5.1	5.0	4.1
(1)	(BNAS-white)	4.6	4.4	5.1	5.1	4.7
128	PI 315345/Acadian	4.1	4.0	4.8	4.9	3.6[c]
LSD 5%		0.2	0.3	0.2	0.2	0.4

[a]All values are means of scores of 51 members of a taste panel with 3 replications. [b]Preference was scored from 7 (highly acceptable) to 1 (highly unacceptable). [c]Flesh color of root was purple.

After 3 years of successively more intense screenings, the cultivar PI 344129 again proved itself resistant (no infection) to the mycoplasma witches' broom disease when tested under heavily infested conditions in Penghu island (off the west coast of Taiwan). Four other cultivars, which were resistant in previous tests, ranged in infection rates from 14 to 100%.

In a series of trials, sweet potato yield and protein content were generally negatively correlated among cultivars (Table 9). However, when we analysed roots from the line 35-2, which had been grown in a management trial under 15 different fertilizer treatments, a positive correlation was obtained between yield and protein content. This result indicates that both yield and protein content might be improved through such management practices as N application.

A substantial part of AVRDC's sweet potato germplasm was increased at the Bureau of Plant Industry's (BPI) Economic Garden in Los Baños and distributed to several agricultural institutions in the Philippines. The largest collection of 503 accessions was delivered to the Visayas State College of Agriculture where the Root Crops Research Center of the Philippines is located.

Cooperators at the Pachong Training Farm in Thailand, the Philippine Sugar Research Institute (PHILSUGIN), La Granja Research and Training Station of the University of the Philippines, and the Institute of Plant Breeding (IPB) in the Philippines reported on the performance of our breeding lines in a variety of trials. AVRDC's selection 35-1 produced a marketable yield of 15 t/ha in a paddy field following rice. This yield was impressive due to the extreme hardness of the paddy soil. They observed that 35-1 developed roundish roots just below the soil's surface.

Table 9. Ranges in yield and protein content on both fresh and dry weight and their respective correlation coefficients in 4 different trials; 1976, AVRDC.

Trial no.	No. of entries	Ranges in yield fresh wt	Ranges in yield dry wt[a]	Ranges in protein content[b] fresh wt	Ranges in protein content[b] dry wt	Correlation coefficients of yield & protein content fresh wt	Correlation coefficients of yield & protein content dry wt
		-------(t/ha)------		--------(%)-------			
I[c]	17	1 to 24	<1 to 6	1.3 to 2.3	4.6 to 8.6	-0.303	-0.041
II[d]	9	6 to 41	2 to 10	0.4 to 1.7	1.6 to 6.5	-0.828**	-0.783**
III[e]	10	12 to 31	3 to 7	1.0 to 1.8	4.5 to 6.6	-0.866**	-0.822**
IV[f]	1	22 to 32	5 to 8	0.6 to 1.1	3.0 to 4.4	0.680**	0.750**

[a]Dried to 105°C. [b]Measured by micro-kjeldahl method. [c]Aug 9 (1974)planting, harvested after 140 days; 3 replications; low management. [d]Spring 1975; 3 replications; high of management. [e]Winter 1975 on farmer's field in Pingtung (S. Taiwan); 6 replications; high management. [f]AVRDC selection 35-2 planted during winter at AVRDC; Data are means of 15 fertilizer treatments; 3 replications.

The Mennonite Central Committee in Bangladesh obtained some of our lines in 1975 from which they were able to propagate and obtain sufficient materials for an observational trial. The results are presented in Table 10. The materials have been further increased and are being shared with the Bangladesh Agricultural Research Council in Dacca.

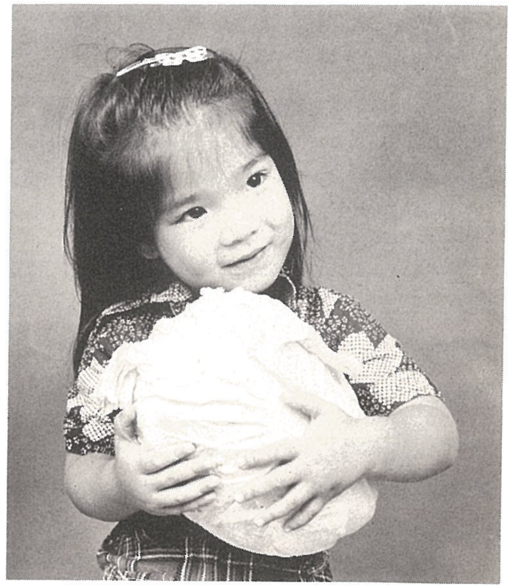
Table 10. Yields of 6 AVRDC breeding lines in an observational trial; 1976, Bangladesh.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield[b]	Flesh color of roots
		(t/ha)	
35-1	HDK 6/B 6708	16	orange
200-2	B 6708/Centennial	11	orange
(4)	(Sweet Potato 45)	9	yellow
230	B 6733/HDK 8	8	orange
35-2	HDK 6/B 6708	6	orange
030-6	Centennial (op)	6	orange
61	Allgood/Tainung 63	4	orange

[a]Data provided by Mr. A. Ryskamp of the Mennonite Central Committee. Trial planted Jan 5 and harvested May 2 (118 days). [b]5.5 m^2 plots were harvested per entry.

Saudi Arabian research worker checks performance of some AVRDC Chinese cabbage lines under desert oasis condition. AVRDC's farm superintendent, now serving on a Chinese Agricultural Technical Mission to Saudi Arabia, assisted in the test plantings.

Chinese Cabbage



CHINESE CABBAGE RESEARCH OBJECTIVES

*Higher yields during the hot, wet season in the lowland tropics

*Varietal resistance to bacterial soft rot, downy mildew, and turnip mosaic virus

*Control of diamondback moth, cabbage looper, cabbageworm, aphids, and other insect pests without residual pesticide

*Decrease in post harvest losses between field and table

At a glance: Cabbage[a] yields and population growth for selected tropical and temperate countries; 1965 to 1974.[b]

Country	Ave. yield 1965	Ave. yield 1974	Change in yield	Population growth; 1965 to 1974
	-----(t/ha)-----		(%)	(%)
Bangladesh	6	7	17	37
China, mainland	11	15	36	17
India	6	6	0	21
Philippines	8	7	-12	35
Taiwan, R.O.C.[c]	10	14	40	25
Thailand	6	6	0	34
Germany, F.R.	28	41	46	5
Japan	27	35	30	11
U. S. A.	18	20	11	9

[a]"Cabbage" category of FAO includes Chinese cabbage. [b]Data from FAO Production Yearbooks, 1970 through 1974, except for Taiwan. [c]Taiwan Agricultural Yearbook, 1975 edition.

We continued to screen our segregating populations of Chinese cabbaqe for tolerance to high temperatures and resistance to soft rot (*Erwinia carotovora*), downy mildew (*Peronospora parasitica*), and turnip mosaic virus (TuMV). The results of the screenings are summarized in Table 1.

Table 1. Summary of various screenings of Chinese cabbage segregating populations for heat tolerance and resistance to major diseases; 1975-76, AVRDC.

Screening for resistance to	Season	Generation	Entries inoculated		Selection	
			plants	lines		
			(1000)	(no.)	(no.)	(%)
Downy mildew & heat[a]	'75 winter	F_2	8.9	20	790	9
Downy mildew	'75 winter	F_2S_1, F_3S_1	2.7	54	391	14
Downy mildew	'75 winter	F_2S_2	0.4	8	20	5
Soft rot & heat	'76 summer	F_2	21.5	83	50	<1
Soft rot & heat	'76 summer	F_2S_1, F_3S_1	35.1	702	126	<1
Soft rot & heat	'76 summer	F_2S_2, F_2S_3	9.3	186	58	<1
TuMV & heat	'76 summer	F_2S_1, F_3S_1	2.4	47	0	0
TuMV & heat	'76 summer	F_2S_2, F_2S_3	6.8	137	0	0

[a]Screened for heat tolerance using the vernalization-photoperiod treatment developed in 1975 (*AVRDC Chinese Cabbage Report for 1975*)

Through a genetic study of heat tolerance, we determined that heat tolerance in Chinese cabbage is controlled by a single recessive gene as the F_2 segregation data from 4 heat-tolerant/heat-sensitive crosses fit the expected 3:1 ratio. Further proof was obtained when the backcross segregation data fit the 1:1 ratio for simply inherited characters. The simple genetic control of heat tolerance should allow us to incorporate it in our breeding lines easily. In other genetic studies, resistance to both soft rot and TuMV appeared to have complete dominance over susceptibility.

In 1975, we determined that heat-tolerant genotypes would bolt earlier than heat-sensitive types when subjected to a seedling vernalization treatment of 5°C and continuous light for 20 days. While using this technique to screen segregating populations during the cooler seasons, we found that (i) survival rate at transplanting was greater when the vernalization period was shorter; (ii) longer seedling vernalization periods effectively accelerated bolting; (iii) a 10- to 12-day seedling vernalization period was optimun for heat-tolerant genotypes; and (iv) when moist presprouted seeds were vernalized one day after sowing, 80% of the plants bolted compared to a 19% rate for seedlings treated 3 days after sowing.

To accelerate our breeding program through vegetative propagation of selected genotypes, we developed a method of culturing axillary buds using modified Murashige and Skoog culture media plus naphthalene acetic acid and benzyladenine.

Two cultivars (Tongil Special and Tongil New 2) were resistant to downy mildew under artificially created epiphytotics at AVRDC in a spring screening. Many of our segregating populations also were resistant to natural epiphytotics of clubroot (*Plasmodiophora brassicae*) during the summer at AVRDC.

Approximately 59% (512) of 873 breeding lines were resistant to soft rot in a field screening under both natural (summer) and artificial epiphytotics. A total of 337 cultivars were evaluated in 4 screenings for resistance to TuMV; 31 entries were selected for resistance.

We screened 70 cultivars in the spring for varietal resistance to a broad range of insect pests, viz., diamondback moth (*Plutella xylostella*), cabbageworm (*Pieris rapae*), striped flea beetle (*Phyllotreta striolata*), and aphids (*Hyadaphis pseudobrassicae & Myzus persicae*). Insect counts were made and an overall damage index was used to determine relative resistance. Six entries had damage indices of 2 or below, indicating that less than 20% of the leaves were damaged by insects (Table 2).

Table 2. The 6 best Chinese cabbage cultivars with relatively low damage from major insect pests in a spring screening; 1976, AVRDC.[a]

AVRDC acc. no.	Cultivar name	Damage index	Diamondback moth	Cabbage-worm	Striped flea beetle	Plants with $\geq$1000 aphids
		(1 to 5)[b]	----(no. of	insects/10	plants)----	(no.)
440	Gunma Chitose	1.7	1.3 cd	8.3ab	14.7a	2a
210	Haekbaechu	1.7	2.7 e	8.7ab	10.3a	0a
206	Konong 5 F_1	2.0	0.3a	14.0abc	7.3a	0a
349	Kinshyu	2.0	1.4 bcd	7.7a	6.3a	3a
389	Tochinishiki	2.0	2.0 de	8.0a	19.3a	2a
445	Bansei Oogota Ogon	2.0	2.0 de	12.3abc	10.3a	1a
Mean (70 entries)		3.5	3.6	22.0	21.4	2

[a]Transplanted Mar 17; sampled Apr 20 & 21; data are means of replications; data followed by same letter are not significantly different at 5% level. [b]1 = <10% of the leaves were damaged; 2 = 10 to 20%.

A preliminary study of the population dynamics of major insect pests on crucifer crops at AVRDC provided the information illustrated in Figure 1 and indicated that populations of most pests were greater on common cabbage. Aphid populations were high in both spring and fall seasons and almost zero during the summer. High temperatures seemed to be detrimental to the development of diamondback moth and striped flea beetle populations.

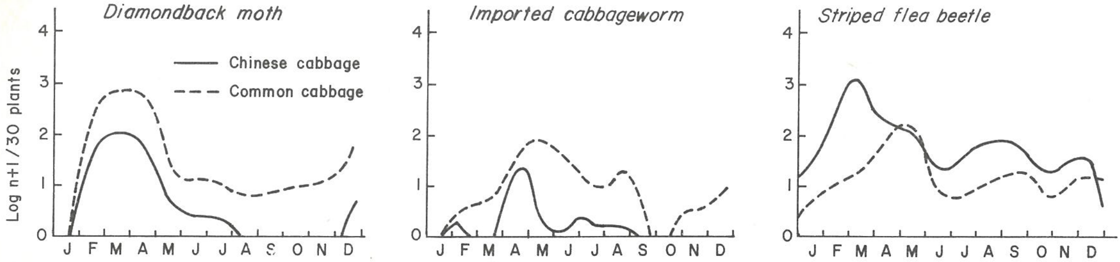


Fig. 1. Variations in populations of major insect pests of cabbage throughout the year on both Chinese and common cabbage; 1976, AVRDC.

Sex pheromone studies of the diamondback moth and cutworms (*Spodoptera litura*) determined that the attractant produced by female moths was effectively masked by inhibitor compounds such as cis-C_{14} aldehyde (A) and cis-9-hexaclecenyl propionate (P) in field tests (Table 3). Male cutworms were readily attracted to 2 sex pheromone analogs (9, 11-TDAA and 9, 12-TDAA).

Table 3. Effect of sex pheromone inhibitory compounds, cis-C_{14} aldehyde (A) and cis-9-hexaclecenyl propionate (P) on the number of male diamondback moths attracted to female moths; 1976, AVRDC.[a]

Treatment[b]	Duration				
	1 day	3 days	5 days	7 days	mean[c]
	(no. of males attracted/day)[d]				
Control[e]	1.0	1.2	1.0	1.0	1.0 b
2 females	12.3	3.8	4.2	2.7	5.2a
2 females + A	1.7	2.6	1.4	1.4	1.6 b
2 females + P	2.6	1.0	1.0	1.0	1.6 b
5 females	11.9	6.3	4.4	3.0	6.4a
5 females + A	2.6	2.4	1.7	1.7	1.7 b
5 females + P	4.4	1.0	1.0	1.2	2.3 b

[a]Cultivar Fung-Li transplanted Mar 10; traps operated May 5 to 11. [b]A = cis-C_{14} aldehyde; P = cis-9-hexaclecenyl propionate. [c]Means followed by same letter are not significantly diggerent at 5% level. [d]Data transformed for analysis by x = y+1; 2 replications. [e]No females in trap.

Further tests reconfirmed the effectiveness of a granulosis virus (GV) in controlling populations of diamondback moth larvae and pupae on cabbage (Table 4).

Table 4. Evaluation of a granulosis virus (GV) of the diamondback moth alone and with various adjuvants and a commercial biological agent for the control of the diamondback moth on cabbage; 1976, AVRDC.[a]

Treatment[b]	Spraying frequency[c]	Diamondback moth larvae & pupae/10 plants[d]					
		Mar 4			Mar 19		
		live	dead	mortality	live	dead	mortality
	(days)	-----(no.)----		(%)	----(no.)----		(%)
GV + 0.5% India ink	7	54a	51	49	106a	18	15
GV + 1% India ink	7	66a	56	46	146abc	33	18
GV	14	67a	54	45	168abcd	32	16
GV	7	72a	56	44	181 bcd	28	14
GV + 1% India ink	14	92a	69	43	159abc	25	14
GV + 0.5% India ink	14	82a	56	40	230 d	40	15
GV + extender[e]	7	56a	37	40	120ab	21	15
GV + extender	14	92a	49	35	190 cd	26	12
Biotrol[f]	7	60a	4	7	187 bcd	9	4
Control		166 b	5	3	887 e	20	2

[a]Common cabbage cultivar KY Cross transplanted Dec 20 (1975); harvested Mar 22; 10 m^2 plots; 4 replications. [b]GV concentration of 10 larval equivalents 1 ℓ (1.9×10^9 GV/ml); Biotrol at 3 kg a.i./ha. [c]Weekly sprayings Feb 6, 13, 20, 27, and Mar 5. [d]Counted at harvest; means followed by same letter are not significantly different at 5% level. [e]Pinolene. [f]Contains 1.5% *Bacillus thuringiensis* spores.

Major insect pests of cabbage were effectively controlled by various synthetic pyrethroid compounds in spring field tests (Table 5). Control was obtained at weekly rates as low as 50 g a.i./ha.

Various new and current insecticides were also evaluated in a spring field trial. Cartap hydrochloride (50% SP) provided the best general control of the diamondback moth, cabbageworm, striped flea beetle, and turnip aphids (Table 6). Control of the flea beetle and aphid populations appeared to increase mean head weight.

We analyzed Chinese cabbage heads that had been treated with some of the insecticides listed in Table 7 for residue at various intervals after the final spraying. By 7 days after the final spraying, most of the residues had degraded substantially (Table 7). We

Table 5. Insect counts one week following last of six insecticide sprays on Chinese cabbage, 1976, AVRDC.[a]

Insecticide[b]	Rate	Mean head wt	Diamond-back moth	Cabbage-worm	Striped flea beetle	Plant with <100 aphids	Plant with >100 aphids
	(kg a.i./ha)	(kg)	(no. /10-plant sample)[c]				
S-5602 (20% EC)	0.05	1.9a	3a	0a	0a	2a	0a
" "	0.50	2.0a	1a	0a	0a	0a	0a
S-3206 (20% EC)	0.05	1.8a	1a	0a	1a	7 bc	0a
" "	0.50	1.8a	0a	0a	0a	4ab	0a
Quinalphos (25% EC))	0.50	1.8a	21a	0a	0a	9 c	0a
Control		0.7 b	682 b	8 b	21 b	5ab	5 b
S-3151 (20% EC)	0.10	1.8a	2a	0a	1a	4a	0a
" "	0.50	1.8a	0a	0a	0a	0a	0a
S-2539 (25% EC)	0.10	1.3 b	108 b	1a	46 c	9 b	0a
" "	0.50	1.2 b	21 b	0a	47 c	9 b	0a
S-2539 (50% EC)	0.10	1.4 b	34 b	0a	36 bc	10 b	0a
" "	0.50	1.4 b	29 b	0a	10ab	9 b	0a
Quinalphos (25% EC)	0.50	1.4 b	76 b	0a	9ab	10 b	0a
Control		0.6 c	808 c	11 b	43 c	3a	7 b

[a]Common cabbage cultivar KY Cross transplanted Jan 16; harvested Apr 12; 10 m^2 plots; 4 replications; Data followed by same letter are not significantly different at 5% level.
[b]Sprayed Feb 10, 17, 24, Mar 2, 9, 16, and 23. [c]Sampled Mar 25.

washed cabbage leaves from another insecticide trial one day after the final spraying and reduced residual concentrations by as much as 76% (Table 8). Carbofuran also provided significant control of diamondback moth and striped flea beetle.

The outer leaves of Chinese cabbage (30% of the total head wt) contained 75 to 99% of the residues of 3 insecticides, whereas the inner leaves were almost free of residues. However, the outer leaves constitute at least one third of the yield. When we boiled the leaves for 20 minutes, the concentrations of Tokuthion, carbofuran, and triazophos in the leaves increased by 12, 186, and 85, respectively. The leaves treated with other insecticides (those listed in Table 8) generally had lower residues after cooking.

Table 6. Insect counts one week following last of six insecticide sprays on Chinese cabbage, 1976, AVRDC.[a]

Insecticide[b]	Rate	Mean head wt	Diamond-back moth	Cabbage-worm	Striped flea beetle	Plant with >1<100 aphids	Plant with >100 aphids
	(kg a.i./ha)	(kg)	(no. /10-plant sample)[c]				
Cartap hydrochloride (50% SP)	1.0	1.2a	6a	0a	2a	8 b	0a
Methidathion (40% EC)	0.5	1.2a	44abc	0a	11a	8 b	2a
Diazinon (60% EC)	0.5	1.1ab	111 d	0a	34ab	10 b	0a
Naled (58% EC)	1.0	1.0 bc	61 bcd	0a	10a	5 b	5a
Acephate (75% WP)	0.5	1.0 bc	107 d	0a	12a	8 b	2a
Salithion (25% EC)	0.2	0.8 cd	76 cd	1a	18a	10 b	0a
Methomyl (90% WP)	0.4	0.8 cd	175 e	0a	89 bc	4 b	6 b
Quinalphos (25% EC)	0.2	0.7 d	2a	0a	2a	6 b	4 b
Control		0.7 d	37abc	2 b	112 c	0a	10 b

[a]Cultivar Fung-Li was transplanted Feb 19; harvested Apr 15; 10 m^2 plots; 4 replications; data followed by same letter are not significantly different at 5% level. [b]Sprayed Mar 3,10,17,24,31, and Apr 6. [c]Sampled Apr 13.

Table 7. Insecticide residues in Chinese cabbage at various intervals after the final spraying of 6 insecticides; 1976, AVRDC.[a]

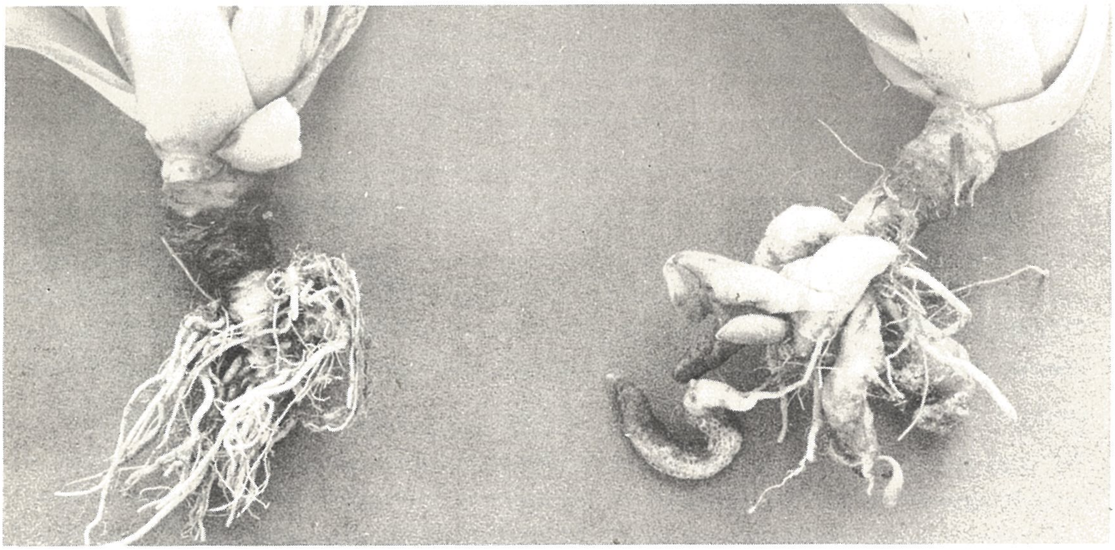
Insecticide	No. of days after final spraying: 0	1	3	7
	(Residue, ppm)[b]			
Methidathion (40% EC)	3.3±2.4	1.2±0.4	0.2±0.1	0.04±0.02
Diazinon (60% EC)	3.3±0.9	0.6±0.3	0.1±0.1	0.03±0.03
Acephate (75% WP)	0.5±0.2	0.2±0.1	0.2±0.1	0.12±0.06
Salithion (25% EC)	9.7±1.8	1.3±0.6	0.1	0.01
Methomyl (90% WP)	1.1±0.2	nd	nd	nd
Quinalphos (25% EC)	31.6±8.4	11.0±5.9	4.4±1.2	1.19±0.66

[a]Same trial reported in Table 7. We lack facilities to check for residues of cartap hydrochloride and naled. Weather conditions for week after final spraying on Apr 6: mean temp, 22.6°C; min temp. 15.6°C; & max temp 30°C and mean relative humidity (RH), 81%; min RH, 50%; & max RH, 100%. [b]nd = not detectable.

Table 8. Reduction in insecticide residues in Chinese cabbage by washing with tap water; 1976, AVRDC.

Insecticide	Rate	Residue		Reduction
		before washing[a]	after washing	
	(kg a.i./ha)	(ppm)		(%)
Carbofuran	0.5	0.87 ± 0.35	0.21 ± 0.04	76
Methamidophos	0.5	0.05 ± 0.05	0.02 ± 0.01	60
Triazophos	1.0	8.83 ± 2.20	4.53 ± 1.23	49
Quinalphos	0.5	3.06 ± 1.46	1.85 ± 0.95	40
Perthane	1.5	17.10 ± 8.33	11.49 ± 4.27	32
Tokuthion	1.0	8.04 ± 2.92	6.51 ± 3.20	19
Chlorpyrifos-methyl	0.5	0.58 ± 0.32	0.50 ± 0.16	14
Fenitrothion	0.5	1.99 ± 0.82	1.90 ± 0.80	4

[a]Residue measured one day after final spraying; crop sprayed Jan 12, 21, 28, Feb 11, and 17.



Normal Chinese cabbage roots (left) compared with roots infected with clubroot (*Plasmodiophora brassicae*).

We evaluated various fungicide treatments for control of downy mildew on Chinese cabbage in a fall screening using artificially enhanced epiphytotic conditions, i.e., two inoculations and excessive irrigation. Mixtures of mancozeb and DPX 3217 provided the best control in this experiment (Table 9).

Table 9. Evaluation of various fungicide treatments for control of downy mildew on Chinese cabbages under artificial and natural epiphytotic conditions in a fall trial; 1976, AVRDC.[a]

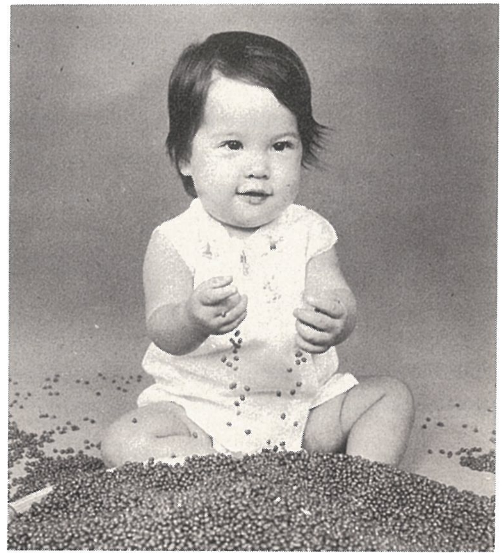
Fungicide treatment	Rate	Marketable yield	Disease index
	(kg a.i./ha)	(kg/20 heads)	(P)[b]
Mancozeb & DPX 3217	1.8	32	35
Mancozeb & DPZ 3217	1.5	32	36
Mancozeb & DPZ 3217	1.2	31	37
Chlorothalonil	2.5	28	42
Chlorothalonil	2.0	26	44
Mancozeb	2.5	26	39
Control		24	50
LSD 5%		6	8

[a]Cultivar Ping-luh (susceptible to downy mildew but resistant to soft rot) was transplanted Oct 13; inoculated Nov 18 and 25; fungicides were sprayed Nov 11, 17, 25, Dec 1, and Dec 8; fungicide suspensions were 6:1, 8:1, 10:1, 10:1, and 10:1; 20 heads were harvested from center of each plot; 4 replications; Irrigated Nov 18, 25, Dec 2, and 9. Surveyed and harvested Dec 21 and 22. [b]Disease index = $\frac{\Sigma (n \times v) \times 100}{N}$ When N = total no. of leaves rated, n = no. of leaves in each of 4 infection categories, and v = numerical values of the inflection categories.

Compost treatments (20 t/ha) increased average plant weight by 20% and yield by 39% in a winter management experiment. Yields of 91 t/ha were obtained with applications of compost, 310 kg N/ha, and a population density of 4 plants/m^2.

Sets of cultivars for yield trials were sent to cooperators in 6 countries. In a trial conducted in the Philippines, 14 heat-tolerant entries were selected for use as parents for recurrent selection. A total of 299 Chinese cabbage seed samples were distributed.

Mungbean



MUNGBEAN RESEARCH OBJECTIVES

*Higher and more uniform yields from early maturing cultivars

*Varietal resistance to *Cercospora* leafspot, powdery mildew, root diseases, and viruses

*Integrated pest control to reduce production losses in the field and in storage

*Higher protein content with improved quality

At a glance: Dry bean[a] yields and population growth of selected tropical and temperate countries; 1965 to 1974.[a]

Country	Ave. yield 1965	Ave. yield 1974	Change in yield	Population growth; 1965 to 1974
	------(t/ha)-----		(%)	(%)
Bangladesh	0.7	0.8	14	37
Burma	0.8	0.8	0	23
China, mainland	0.7	0.7	0	17
Ethiopia	0.7	0.8	14	21
India	0.2	0.3	50	21
Philippines	0.4	0.4	0	35
Sri Lanka	0.8	0.6	-25	24
Taiwan, R. O. C.	0.7	0.7[c]	0	25
Thailand	1.1	1.1	0	34
Japan	1.2	1.4	17	11
Netherlands	1.9	2.6	37	10
U. S. A.	1.4	1.5	7	9

[a]"Dry beans" category of FAO includes mungbean. [b]Data from FAO Production Yearbooks, 1970 through 1974. [c]Data for mungbean from Taiwan Agricultural Yearbook, 1975 edition.

More than 375 crosses were made to combine the resistance to major diseases such as *Cercospora* leaf spot (*C. canescens*), powdery mildew (*Erysiphe polygoni*), and mungbean mottle virus (MMV) of selected Indian lines with the higher yield potential and uniform maturity of various Philippine cultivars. The Philippine line, PHLV 18, was used as a parent in 168 single and multiple crosses.

In 1976, Mungbean yields were considerably higher during the summer season with a mean yield of 2 t/ha for a trial of 20 elite cultivars (Table 1). Although yields in spring and fall trials were generally lower than for similar trials in 1975 (*AVRDC Mungbean Report for 1975*). The mean maturity indices for the entries in the summer trial were all lower than the lowest indices of entries in the spring and fall trials. Other characters such as plant height were similarly affected. The cultivars PHLV 18 and KJ 5 (M 350), two of the highest yielders in 1975, had yields of 2.7 t/ha in the summer trial (Table 2). The early maturing PHLV 18 produced 1.9 t/ha of mungbean at 55 days after planting. Another 0.8 t/ha was obtained in 4 subsequent harvests.

Table 1. Summary of yield, yield components, and maturity for 3 trials of elite mungbean cultivars; 1976, AVRDC.

Character	Spring trial[a]		Summer trial[b]		Fall trial[c]	
	mean	range	mean	range	mean	range
	(N=29)		(N=20)		(N=40)	
Yield (t/ha)	1.0	0.4 to 1.6	2.0	1.2 to 2.7	0.9	0.4 to 1.2
Production rate (kg/ha per day)	13	4 to 20	32	18 to 45	10	5 to 13
Pods/plant (no.)	21	9 to 30	23	14 to 32	14	7 to 26
Seeds/pod (no.)	11	9 to 13	12	11 to 14	11	9 to 13
1000 seed wt (g)	46	25 to 62	49	32 to 79	64	42 to 101
Plant ht (cm)	48	28 to 68	89	76 to 104	37	23 to 51
50% flowered (days)	44	40 to 52	36	31 to 42	36	29 to 40
Mean maturity index[b]	81	75 to 90	63	60 to 67	75	67 to 82

[a]Sown Mar 23. [b]Sown Jul 14. [c]Sown Sep 24. [d]Mean maturity index equals the sum of the no. of days from planting to each harvest multiplied by yield at each harvest divided by total yield.

Ten of the elite cultivars were also tested during the wet season at the BPI Economic Garden in Los Baños (Philippines). The Indian cultivar ML-6 produced the highest yield of 2.5 t/ha, while the local cultivar MG 50-10A yielded 1.4 t/ha. The average yield of the 10 entries was 1.9 t/ha.

Table 2. Yield, daily production rates, and mean maturities of 7 elite mungbean cultivars in 3 seasonal yield trials; 1976, AVRDC.[a]

AVRDC acc.no.	Cultivar name	Yield				Daily production rate			Mean maturity index		
		spring	summer	fall	mean	spring	summer	fall	spring	summer	fall
		(t/ha)				(kg/ha per day)			(days)		
2984	KJ 5	1.3	2.7	1.2	1.7	16	44	13	79	61	75
2007	M 304	1.0	2.6	1.1	1.6	15	42	12	78	62	73
2184	PHLV 18	0.9	2.7	1.2	1.6	12	44	12	78	61	71
1776	M 804	1.5	2.4	0.8	1.6	20	38	9	77	63	75
3092	M 333	1.5	2.1	1.0	1.6	19	34	11	78	62	74
1381	MG 50-10A (G)	1.1	2.3	0.8	1.4	15	38	8	75	60	76
3476	CES 10-21	1.1	2.1	1.0	1.4	15	34	10	82	62	82
HSD 5%		0.5	0.7	0.6					6	3	8

[a]See footnotes of Table 1.

Approximately 500 new entries to AVRDC's *Vigna* sp. germplasm were screened for sensitivity to photoperiod and 40% had about the same duration to flowering in both 12- and 16-hr photoperiods. Although mungbean is generally considered to be a short-day crop, 10 cultivars consistently flowered earlier under 16-hr photoperiod than 12-hr photoperiod in both spring and fall screenings.

We continued to analyse the mungbean plant to develop criteria to use in screening for high yield. Our experiments confirmed 1975 findings that the higher yielding cultivars such as M 304 and PHLV 18 were able to translocate a higher proportion of photosynthate to the reproductive organs (Table 3) even though they were substantially lower in total dry matter than cultivars with less yield (Table 4).

The higher yielding cultivars had greater accumulations of soluble sugar and starch in the stems and roots compared to the lower yielding entries in a preliminary experiment. There were no significant differences in either the concentration or distribution of nitrogen among the 5 cultivars.

We confirmed our 1975 finding that specific leaf weight (i.e., leaf dry weight per unit of leaf area) at the initiation of flowering is correlated to yield (r = 61**) and therefore may serve as a criterion in screening for high yield potential.

When leaf-water potential was below -2 bars, there was a drastic reduction in the net photosynthetic rate of mungbean, indicating an extreme sensitivity to water stress. The response to water stress varies for different growth stages and cultivars.

Table 3. Ratios of the dry matter weight of the reproductive (R) parts to the vegetative (V) parts of 5 mungbean cultivars; 1976, AVRDC.

AVRDC acc. no.	Cultivar name	Days after emergence 62	72
		--------(R:V)----------	
2007	M 304	0.62	1.08
2184	PHLV 18	0.61	1.05
2273	ML-6	0.20	0.92
2013	Tainan 1	0.12	0.68
2092	CPI-30755A	0.05	0.30
Mean		0.32	0.80
LSD 5%		0.19	0.27

Table 4. Yield dry weight, yield components, and harvest indices of 5 mungbean cultivars; 1976, AVRDC.[a]

AVRDC acc.no.	Cultivar name	Yield	Total dry wt	Pods/ plant	1000-seed wt	Days to 1st flower	Days to 50% flower	Harvest index[b]
		----(g/m^2)---		(no.)	(g)	----------(no.)-------		(%)
2007	M 304	248	551	19	52	42	46	45
2184	PHLV 18	239	558	17	70	41	45	43
2273	ML-6	208	801	27	37	42	47	26
2013	Tainan 1	207	644	21	42	44	49	32
2092	CPI-30755A	130	753	13	40	45	57	17
LSD 5%		33	89	4	3	1	1	1

[a]Grown in the field during the spring season; spacing was 10 cm x 40 cm. [b]Seed yield divided by total biological yield.

In nutritional quality evaluations, the highest protein efficiency ratio (PER) was obtained when 25 and 75% of the protein came from mungbean and rice, respectively (Fig. 1). The PER of rice supplemented with mungbean was 2.44 and was close to the PER value of casein, 2.55. The protein contents of mungbean and rice in this experiment were 25 and 9%, respectively. At the 25:75 mungbean to rice protein ratio, the actual weight ratio was 12:88. Food balance sheets for India, Indonesia, Taiwan, Thailand, Korea, and the

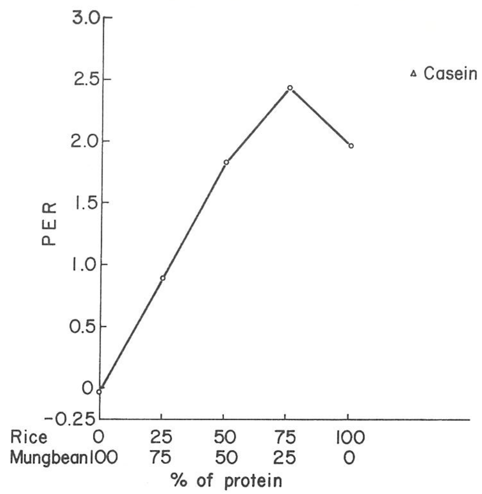


Fig. 1. Protein efficiency ratios (PER) of different combinations of rice and mungbean protein; 1976, AVRDC.

Philippines indicate that the current legume (and nuts) to cereal protein ratios are 26:74, 25:75, 20:80, 14:86, 11:89, and 6:94, respectively. A higher methionine content might be required for those with high legume to cereal protein ratios.

We analyzed 91 mungbean, 128 black gram, and 152 mungbean/black gram F_6 lines for total and available methionine content. The distributions of methionine per unit of protein are illustrated in Figure 2.

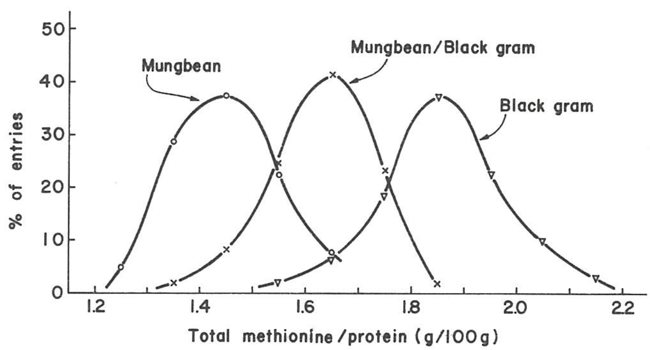


Fig. 2. Comparison of mungbean, black gram, and progeny of mungbean/black gram crosses by total methionine content per total protein content; 1976, AVRDC.

In a series of field screenings using artificial inoculation; 12 cultivars were resistant to powdery mildew, 17 cultivars were resistant to *Cercospora* leaf spot, and 23 cultivars were resistant to MMV. The Indian cultivar OB 24-1 (AVRDC acc. 1877) was resistant to damping off (*Rhizoctonia solani*) in a spring trial. Another Indian cultivar, M 162 (AVRDC acc. 1103), was moderately resistant in spring and fall trials.

BCM at 1.5 g a.i./ℓ and benomyl at 0.6 g a.i./ℓ provided the best protection from *Cercospora* leaf spot in a summer planting of a highly susceptible cultivar under artificially enhanced epiphytotic conditions (Table 5).

Table 5. Evaluation of 2 fungicides at different rates for effective control of *Cercospora* leaf spot on a highly susceptible mungbean cultivar; 1976, AVRDC.[a]

Fungicide	Rate	Yield	1000-seed wt	Disease index
	(g a.i./ℓ)	(t/ha)	(g)	(%)
BCM 65	1.5	1.5	52	5
Benomyl (50 WP)	0.6	1.5	53	7
Benomyl (50 WP)	0.3	1.3	52	16
BCM 65	1.0	1.3	52	19
BCM 65	0.5	1.2	52	23
Benomyl (50 WP)	0.15	1.1	51	30
Control		0.6	49	96
LSD 5%		0.26	2	3

[a]Cultivar M 304 was sown Jun 18; irrigated Jul 23 and 29; inoculated Jul 16, 23, and Aug 2; fungicides were sprayed Jul 15, 29, Aug 6, 12, and 19; surveyed Aug 20; harvested Aug 16 to Sep 10; 4 replications.

Only 16 mungbean cultivars were identified as relatively resistant to beanfly (*Melanagromyza phaseoli*) in a series of 8 screenings conducted at 2-week intervals beginning July 30 and involving a total of 940 cultivars. These selections will be subjected to further testing to confirm their resistance. Another 13 mungbean cultivars (including the high yielding PHLV 18 and MG 50-10A g) were consistently free of infestation from cowpea aphids (*Aphis craccivora*) in successive testings involving 100 entries.

Several insecticides were evaluated for control of beanfly on mungbean. Carbofuran and DDT provided the best control in a spring screening (Table 6).

In a spring experiment weed competition caused a 70% reduction in yield. One weeding at 20 to 30 days adequately controls weed competition during the dry spring season as the competition was most severe during the first month of growth.

Farmers in Southeast Asia often broadcast mungbean in paddy fields and their average yields of 0.5 to 0.8 t/ha are much lower than the yield potential of the crop given a higher level of management. We conducted a series of experiments with a research intern from the Philippines to compare the effects of different cultural practices. We sowed mungbean following a rice crop and to approximate farmers' conditions, applied low levels of

Table 6. Evaluation of insecticides for control of beanfly on mungbean; 1976, AVRDC.[a]

Insecticide	Rate	Yield	Immature beanflies	Damaged stems	Damage rate
	(kg a.i./ha)	(t/ha)	--(no./30 plants)---		(%)
Carbofuran (40.64% F)	2	1.3a	1a	7a	24a
DDT (16.42% EC)	0.5	1.3a	2ab	9a	29a
Dieldrin (13.93% EC)	0.25	1.3a	5 cde	12abc	42 bc
EPN (45% EC)	0.25	1.3a	7 e	16 cd	52 cd
Methomyl (90% WP)	0.25	1.2a	2abc	14 bcd	45 bcd
Phoxim (50% EC)	0.25	1.2a	3abcd	16 cd	54 cd
Diazinon (60% EC)	0.25	1.2a	4 cde	11ab	36ab
Control		1.1 b	6 de	17 d	57 d

[a]Cultivar Tainan 1 was sown Feb 26; insecticides applied Mar 15, 22, and 30; granular insecticides top dressed at sowing; 10 m^2 plots; 4 replications; data followed by same letter are not significantly different at 5% level; harvested May 26, Jun 1, and Jun 6.

fertilizer. The tilled plots had the highest yields (Fig. 3), indicating the positive response of mungbean to higher management. When mungbeans were dibbled near rice straw, the increased soil-seed contact appeared to give better plant stands, whereas the plants in the burned rice straw treatment may have benefited from the extra nutrients left in the ash. Mulching definitely improved the germination of the broadcast seed.

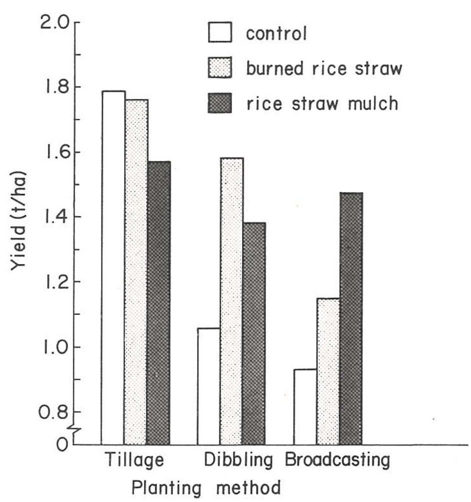


Fig. 3. Effect of planting method, rice straw mulch, and burned rice straw on mungbean yield; 1976, AVRDC.

Training

AVRDC's research and production training programs offer a wide range of opportunities to vegetable research workers and production specialists in tropical countries. The participants in AVRDC's training programs learn by doing at the side of AVRDC's scientific staff. Upon their return home, they strengthen national programs and serve as valuable cooperators in the testing of AVRDC breeding materials, etc. under local conditions.

During 1976, 57 trainees from 9 countries participated in the various training programs at AVRDC. By the end of 1976, AVRDC had provided 27.1 man-years of training (Table 1).

A training brochure, which describes the training opportunities at AVRDC in greater detail, is available upon request from the Training Officer.

Table 1. Countries sending training participants to AVRDC (cumulative total for 1974, 1975, and 1976).

Country	Research oriented			Production training	other[a]	Total	Equivalent man-years of training[b]
	intern	scholar	fellow				
	(no. of participants)						(yr)
India	1					1	0.5
Indonesia	2			2		4	1.6
Korea	5			1		6	2.8
Micronesia	1					1	0.1
Pakistan			1			1	1.1
Philippines	9	1		14		24	10.0
Republic of China	2			6	21	29	6.4
Surinan				1		1	0.3
Thailand	5	1				6	1.9
U.S.A.	1	1				2	2.4
Total	26	3	1	24		75	27.1

The names, countries, and major projects of participants in AVRDC's research training program during 1976 are listed below.

Research interns:

Hemant S. Bedekar, India. (1) Varietal reaction of tomato to different mixtures of bacterial wilt isolates and (2) evaluation of seed yield and other horticultural traits of promising AVRDC tomato selections.

Elena M. Catipon, Philippines. (1) Study of harvest methods for mungbean and (2) observation and evaluation of AVRDC's mungbean germplasm.

Evangelyn Ceriales, Philippines. (1) Intercropping of Chinese cabbage with corn and tomato and (2) research management.

Young-Hyun Hwang, Korea. (1) Seed increase and generation advance of Korean soybean lines, (2) study of F_1 lines from Korea, (3) interspecific hybridization in the genus *Glycine*, and (4) study of the influence of photoperiod on flowering and pod fromation in soybean.

Yung-Chung Kuo, R.O.C. (1) Biological nitrogen fixation and gas chromatographic analysis.

Rosita R. Matias, Philippines. (1) Regional soybean yield trial, (2) photoperiod screening of soybean lines, (3) observation and evaluation of AVRDC's soybean germplasm, and (4) interspecific hybridization in the genus *Glycine*.

Chairerg Sagwansupyakorn, Thailand. (1) Vernalization requirements of Chinese cabbage, and (2) effects of photoperiod, grafting, and some chemicals on flora induction in sweet potato.

Jin-Young Yoon, Korea. (1) Varietal screening for resistance to downy mildew, turnip mosaic virus, and bacterial soft in Chinese cabbage and (2) residual genetic variances on two Chinese cabbage populations after one cycle of recurrent selection.

Teodora H. Cruz, Philippines. (1) Comparative effects of different planting and mulching methods on mungbean yield and (2) evaluation of agricultural research agencies in Taiwan.

Harnoto, Indonesia. (1) Evaluation techniques for resistance to beanflies, bean aphids, spider mites; (2) insecticide evaluation for the legume insect pests; and (3) survey of legume insect pests research in Taiwan.

Seung Jin Kim, Korea. (1) screening virus resistant F_1 hybrid of tomato.

Mi Suk Ko, Korea. (1) Diallel analysis of several economic characters in mungbean, (2) yield trial of 20 elite mungbean varieties, and (3) inheritance study on the resistance to powdery mildew in mungbean.

Benjamin M. Legaspi, Philippines. (1) Missing hills on experimental plots of two soybean genotypes and (2) effects of insecticide fungicide on the performance of three mungbean cultivars.

Jaime B. Rebigan, Philippines. (1) Reaction of three tomato cultivars to heavy rainfall and excessive soil moisture, (2) effect of grafting and brick method,gibberelic acid application and light on flower induction and crossability of white potato, and (3) evaluation of glycoalkoloid content of some AVRDC white potato breeding lines.

Chin-Chih Wang, R.O.C. (1) Studies on the reactions of some tomato varieties to the bacterial wilt pathogen and host range and (2) serological studies on the tomato strain of potato virus.

H. F. Hechanova, Philippines. (1) Soybean yield trial.

Rolando T. Serapio, Philippines. (1) Soybean yield trial.

Vicente P. Tamondong, Philippines. (1) Soybean yield trial.

Vicente J. Rabe, Philippines. (1) Yield performance of two mungbean varieties under different intercropping patterns with corn.

Lolita N. Ragus, Philippines. (1) Field evaluation of five mungbean varieties and (2) comparative study of three harvesting methods on mungbean.

Gap Chae Chung, Korea. (1) Calcium and boron contents in the mature leaves of Chinese cabbage as affected by different nitrogen levels.

Rong Shang Liu, R. O. C. (1) Yield trial of promising sweet potato selection.

Jiun Yih Kuo, R. O. C. (1) White potato yield trial.

Ying Ren Chen, R. O. C. (1) Performance of tomato under irrigated and nonirrigated conditions.

Marius E. Olf, Surinam. (1) Multiple cropping.

Summer students:

Ting-Ching Deng, R. O. C. (1) Studies on uredospore germination of soybean rust.

Ann-Shiou Cheng, R. O. C. (1) Evaluation effect of fungicides on uredospore Phakopsora pachyrhizi by a detached leaf technique.

Su-hua Chen, R. O. C. (1) Heat stability of sweet potato trypsin inhibitors.

Wang-Ting Hsieh, R. O. C. (1) Microbiological assay of mungbean protein quality.

May-May Chen, R. O. C. (1) Phytate content of soybean and mungbean.

Su-Chen Pan, R. O. C. (1) Extraction and analysis of insecticide residues in sweet potato and white potato.

Chih-Hong Cheng, R. O. C. (1) Investigation into the Cleistogamy in soybean.

Yong-Zong Tsai, R. O. C. (1) Evaluation of seed quality in soybean germinability of newly harvested soybean seed from different genotypes.

Chia-Chie Chen, R. O. C. (1) The effect of waterlogging and N-Benzyladenin on growth of tomato plants at AVRDC.

Wen-Liang Kuo, R. O. C. (1) Starch synthetase, phosphorylase, and UDP-glucose phrophosphorylase in developing mungbean seeds.

Shwu-Ming Huang, R. O. C. (1) Evaluation of insecticides for the control of insects on common cabbage and (2) study on biology of giant Agrican snail and natural enemy control in laboratory.

Lih-Shan Lin, R. O. C. (1) Study on the life cycle of the cowpea weevil, (*Callosobruchus chinensis*), at the AVRDC controlled environment room 27°C, 70-80% RH and (2) study on the life cycle of the sweet potato weevil, *Cylas formicarius elegantulus*, in the AVRDC controlled environment room at 27°C, 70-80% RH.

Kuo-Chin Lin, R. O. C. (1) A study of the life cycle of beanfly at the AVRDC controlled environment room, 27°C, 70-80% RH and (2) a preference test of sweet potato weevil, *Cylas formicarius elegantulus*, for selected sweet potato varieties at the AVRDC controlled environment room 27°C, 70-80% RH.

Li-Chen Yung, R. O. C. (1) Insect collection.

Mai-Yung Yeh, R. O. C. (1) Study of the life cycle of the diamondback moth *Plutella xylostella* L. at the environmentally controlled room, 27°C, 65-89% RH, in AVRDC.

Research scholars:

James A. Deutsch, U. S. A. (1) Variability and inheritance of components affecting yield, nutritional value, and acceptability of *Amaranthus* sp. as a leafy vegetable.

Aphiphan Pookpakdi, Thailand. (1) The relationship between leaf growth and yield components of soybean grown under different plant populations and environment.

Research fellow:

Akhtar U.I. Khwaja, Pakistan . (1) Nitrogen responsiveness of soybean (*Glycine max*. L. Merr.) under different AVRDC soil fertility conditions.

Production Trainees:

Renato C. Mabesa, Philippines. (1) Foliar application of micronutrients on Chinese cabbage and (2) white potato seedpiece multipication.

Concepcion E. Magboo, Philippines. (1) Foliar application of micronutrients on Chinese cabbage and (2) yield and yield components of two sweet potato varieties at three harvest periods.

Wilfredo N. Sierra, Philippines. (1) Foliar application of micronutrients on Chinese cabbage and (2) white potato seedpiece multiplication.

Antoro Wasito, Indonesia. (1) Foliar application of micronutrients on Chinese cabbage and (2) influence of kinds and methods of nitrogen fertilizer application on the yield of Chinese cabbage.

Yih-Horn Chang, R. O. C. (1) Effect of calicum superphosphate and boron in Chinese cabbage and (2) yield comparison among three white potato cultivars using two planting methods.

Ing-Lung Chen, R. O. C. (1) Effect of calicum superphosphate and boron in Chinese cabbage and (2) yield comparison among three white potato cultivars using two planting methods.

Shian-Liang Hwang, R. O. C. (1) Effect of calicum superphosphate and boron in Chinese cabbage and (2) yield comparison among three white potato cultivars using two planting methods.

Rodolfo G. Flores, Philippines. (1) Effects of compost and varying levels of complete fertilizer (NPK) on the yield of tomato and (2) yield comparison between two mungbean varieties using two planting methods.

Demetrio V. Oria, Philippines. (1) Effects of compost and varying levels of complete fertilizer (NPK) on the yield of tomato and (2) yield comparison between two mungbean varieties using two planting methods.

Amado B. Ragasa, Philippines. (1) Effects of compost and varying levels of complete fertilizer (NPK) on the yield of tomato and (2) yield comparison between two mungbean varieties using two planting methods.

Angelina Macaso, Philippines. (1) Resonse of mungbean varieties to NPK applied alone and in combination on calcareous soils of AVRDC.

Kernawidjaja Subandi, Indonesia. (1) Yield trial of elite soybean cultivars and breeding lines.

Miguel J. Catipon, Philippines. (1) Soybean yield trial.

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++ On leave for 2-year mission to Saudi Arabia.

Publications

AVRDC's Office of Information Services (OIS) edited, published, and distributed 5000 copies of the AVRDC Progress Report for 1975 to researchers, libraries, professors, students, extension workers, and administrators in 132 countries. Separate reports were also prepared for specific research activities on soybean, tomato, sweet potato, mungbean, and Chinese cabbage and distributed upon request. OIS published about 15,500 copies of the various 1975 reports for AVRDC.

An information card was attached to our 1975 reports (one is also included with this report) and by June 1977, more than 900 cards (20%) had been returned. Through these cards, we were able to efficiently distribute our various crop reports and almost 5000 copies of AVRDC's technical bulletins, journal papers, and reprints. We also found that many readers were able to use the cards to join our mailing lists. The information compiled from the cards will be used in the development of an information service for vegetable researchers and extension workers in the tropics.

AVRDC makes available, upon request, reprints of technical papers written by its staff members. These papers may be obtained by writing the desired title (TB & JP series) on the card provided at the beginning of this publication, checking the appropriate squares, and mailing the card to AVRDC. Be sure to include your complete mailing address. All AVRDC publications are free and will be sent by surface mail. The following publications list replaces all previous lists.

AVRDC Technical Bulletin Series (TB):

TB 1 Menegay, M. R. 1975. Taiwan's specialized vegetable production areas: an integrated approach.

TB 2 Menegay, M. R. 1976. Farm management research on cropping systems.

TB 3 Calkins, H. 1976. Four approaches to risk and uncertainty in farm management extension.

AVRDC Journal Paper Series (JP)

JP 1 MacKenzie, D. R., L. Ho, T. D. Liou, Henry B. F. Wu, and E. B. Oyer. 1975. Photoperiodism of mungbean and four related species. HortScience, Vol. 10(5): 486-487.

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