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AVRDC PROGRESS REPORT '75

"The farmer is our client; it is he whom we must serve. Any other objective is trivial compared with our aim to improve the well-being of the rural population and to strengthen agricultural production." (Robert F. Chandler, Jr., 1975)

this is the

ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER'S

PROGRESS REPORT FOR 1975

About this report

This report briefly presents a summary of the research, training, and outreach activities of the Asian Vegetable Research and Development Center (AVRDC) during 1975.

For persons desiring to remain on our mailing list or wishing additional information, a detachable form is included with this report. Please give us your complete mailing address.

Research reports have been published summarizing 1975 activities for soybean (*Glycine max*), tomato (*Lycopersicon esculentum*), sweet potato (*Ipomoea batatas*), mungbean (*Vigna radiata*), Chinese cabbage (*Brassica pekinensis*), and white potato (*Solanum tuberosum*).

Data are presented in metric units, and monetary values are expressed as U.S. dollars at the prevailing exchange rates.

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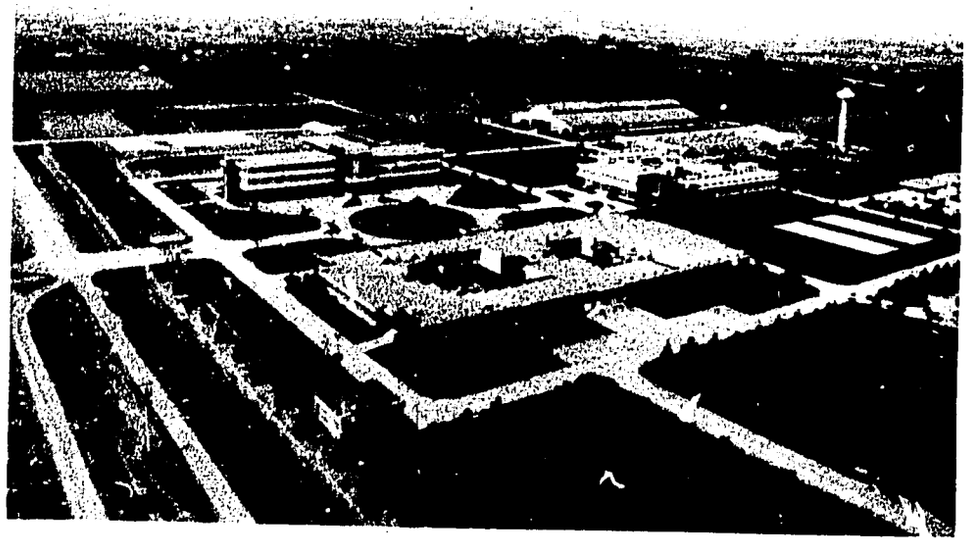

The Asian Vegetable Research and Development Center (AVRDC) is the international agricultural research organization responsible for improving the production and quality of vegetable crops in the humid tropics. The Center occupies 116 hectares of land and is 19 kilometers north of Tainan City in Southern Taiwan. The climate is tropical most of the year, and vegetables are grown year-round.

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NOT ENOUGH FOOD

> *"Providing sufficient food to meet the needs of an ever-increasing world population is one of the greatest challenges mankind has ever faced..." (Consultative Group on International Agricultural Research, 1974)*

Current projections indicate that the world community, which reached the 4 billion mark sometime in 1975, will number 5 billion by 1989 and 6 billion at the turn of the century. The 'Borlaug breather' given the world by the 'miracle seeds' of the late sixties is over; population again appears to be overtaking food production in the never-ending malthusian race that once more threatens the well-being of mankind.

Present food production can hardly be considered adequate--statistics are generally undigestible, and only a vague idea of aggregate production and consumption can be obtained from even the best available analysis. Inadequate marketing and distribution systems mean that so-called self sufficiency in food production is based on what the 'market' will move rather than adequate food supplies for one and all.

Not only is the world lagging behind in the production and distribution of foodstuffs, particularly among the hungry poor who often can not pay for their food even if it is available, but the nutritional quality of the food produced is beginning to be of concern. No one can doubt the critical importance of such cereal grains as rice, wheat, and corn for the world's hungry multitudes. Yet, it is becoming increasingly more obvious that these grains, even if consumed in quantities sufficient to meet caloric needs, do not supply adequate amounts of protein, vitamins, and minerals to meet basic nutritional requirements.

> *"During the third quarter of this century, overall global food production kept pace with the population growth. Sugar and fat production grew faster than the population, but legumes, a key supplement for the cereal-eating billions, lagged behind, resulting in a deteriorating nutritional situation. The overall gains took place mostly within the well-fed world; the hungry world barely managed to strike a balance. In Asia, the increase rose briefly to 7%, still shockingly low when compared to the 50 to 100% increase needed to fill existing nutritional needs." (Georg Borgstrom, 1976)*

It is difficult to estimate what percentage of the world's population suffers periodically from malnutrition, because the criteria for such judgments are not easily established. However, the World Health Organization, through numerous clinical surveys of preschool children in developing countries, has reported that nearly one-third of the children of Asia are malnourished; the figures for Africa and Latin America are 20 to 25%.

"We want our children to read. We don't want them to be sick all their lives, and we want to grow our own food on our own land." (Vietnamese Village Chief)

More food! Better nutrition! Rural employment! These appear to be the new, urgently uttered buzz words of development. The small farmer is being re-discovered, but we still don't quite know what to do with him--when ignored, he produced only for himself; when stimulated with promises of a better tomorrow, he left his fields for urban slums.

"Without rapid progress in smallholder agriculture...there is little hope either of achieving long-term stable economic growth or of significantly reducing the levels of absolute poverty." (Robert McNamara, 1973)

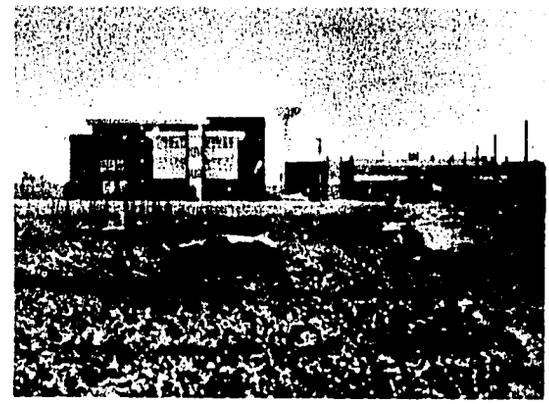
The food for tomorrow in most countries will come from the efforts of millions of small farmers. Technology must be developed to enable him to produce enough food to feed both himself and his urban neighbors. In many countries, agriculture must also productively absorb more labor. There are indications that this can be achieved, but only with a great deal of effort, applied research, and commitment.

"At present the incomes of nearly a billion people depend upon farms of less than 5 hectares...but on these mini-holdings output per hectare can be a third as large again as in the largest farms.... here is the critical gap in capital, productivity, and, above all, food that the new development approach is beginning to put at the center of its strategy." (Barbara Ward, 1973).

The world is now increasingly confronted with shortages in each of the four basic agricultural resources, viz., land, water, energy, and fertilizer. Small farmers in tropical regions have coped with such 'shortages' for centuries. The days of 'cheap' energy are over; the only cheap energy these farmers used regularly was their own. Now, greater demand is being exerted on scarce resources, and while the small farmer is being urged to contribute more to the world's food supplies, there is little evidence to suggest that his share of the basic resources will be proportionally increased.

Therefore, appropriate technology must be developed to exploit the longer growing seasons of the tropics by breeding plants that are more efficient converters of available resources into food. Attention also needs to be focused on the improvement and use of nitrogen-fixing plants in rotational cropping systems. Plant types that produce well under conditions of low fertility, without chemical pesticides, and with an efficient use of labor

Scientists consider every feasible technological option, particularly those within reach of the small tropical farmer, when conducting their experiments.



must be developed. Despite their high humidity, many tropical locations have a period of little or no rainfall ranging from two to seven months. Crops able to endure water stress must be developed for such dry seasons.

> *"Most of the increase [in food production] must come from the developing countries themselves...and most of it must come by increasing the productivity of land already under cultivation." (Consultative Group on International Agricultural Research, 1974)*

As arable land becomes more limited, farmers must harvest as many crops as possible from each field in order to increase food production. The equatorial latitudes are well endowed with solar energy, rainfall, and temperatures favorable to year-round crop production. Fortunately, such potential is greatest where hunger and malnutrition are most prevalent--in the tropics.

This potential is well illustrated by the efforts of Taiwanese farmers who expanded Taiwan's multiple-cropped area from 18% of the total cropland in 1946 to where they are now harvesting an average of nearly two crops on all their land. It has been estimated that about half the farmland on the China mainland is double cropped, whereas only about 18% of India's fields in the early seventies were being exploited in this way.

Farmers in Taiwan have skillfully overcome the island's shortage of arable land by employing various multiple cropping schemes to increase food production.

Asia's Growing Food Woes: More People, Less Farmland

BANGKOK (AP) — Asians will have to rely increasingly on multiple cropping and higher agricultural yields per acre to win the battle against skyrocketing population and shrinking arable land in the region, a U.N. report says.

The 1975 annual report of the [illegible] Development Program, re- [illegible] the follow-

To sustain the growing population even at the present low level of nourishment, it would be necessary to increase food production in the Asian and Pacific region at a minimum annual rate of 4 per cent.

Prospects for this are bleak, since the agricultural growth rate in the region averaged about 2.6 per cent annually during the past 15 years. Shrinking [illegible] another

multiple cropping and higher agricultural productivity.

The report indicated that action had to be taken quickly since the numerous inputs needed to spur production have a long "gestation period." These imputs include irrigation, pest control, fertilizers and new high-yielding seed varieties.

The report stressed that Asia and the Pacific generally needed assistance in land reform, more [illegible] marketing and [illegible] credit [illegible] re-

Today's headlines repeatedly direct our attention to the fact that 20 to 25% of the children in the world's poorer countries do not live to age five mainly because of malnutrition. This is a daily tragedy whose scope is immensely greater than that of earthquakes or floods--but we seem to have learned to 'live' with it. Malnutrition takes several forms and has many causes with only one known cure--adequate food from beginning to end. Yet, it is not enough to produce or consume an adequate quantity of food; we must be concerned about food quality as well if we wish for healthy populations, strong of mind and body, who can achieve the ambitious goals of development.

> *"The light of curiousity absent from children's eyes. Twelve-year-olds with the physical stature of eight-year-olds. Youngsters who lack the energy to brush aside flies collecting about the sores on their faces. Agonizingly slow reflexes of adults crossing traffic. Thirty-year-old mothers who look sixty. All are common images in developing countries; all reflect inadequate nutrition--all have societal consequences."*
> *(Allan Berg, 1973)*

The problem of hunger manifests itself not only in terms of starvation and death, but also in the mental deprivation that results from protein, vitamin, and mineral deficiencies. Far too many children in the tropics suffer from protein malnutrition, particularly at the critical stages of their development. Even babies who receive adequate protein while being breast-fed, often experience protein deficiencies after weaning because of the change from mother's milk to a diet of cheap, starchy, easily digestible 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 nutrients. Protein shortages in the early years of life impair the development of the brain and the central nervous system, thus preventing the realization of genetic potential and permanently reducing learning capacity.

"Unfortunately, some of the effects of malnutrition in the early years of life are lasting and irreversible. No amount of compensatory feeding, education, or environmental improvement in later life can repair the damage to the central nervous system. Protein shortages today are depreciating the stock of human resources for at least a generation to come." (Lester Brown, 1974)

Available evidence suggests that such vitamin-deficiency diseases as rickets, scurvy, and beriberi are major problems in only a few areas of the world today. However, vitamin A deficiency and iron-deficiency anemia continue to be significant nutritional problems throughout much of the world. Inadequate levels of vitamin A are a major cause of blindness and eye diseases for many millions in India, Indonesia, Bangladesh, and the Philippines. Anemia, which results in sluggishness, fatigue, and generally poor health, affect important portions of the population in many nations, rich and poor alike. Expectant mothers are especially susceptible to anemia, which increases the chances of death or illness to the mother as result of pregnancy and childbirth, and also impairs the health of the newborn infant.

Major causes of malnutrition include reliance on a single plant food source--generally a cereal staple, poor socioeconomic conditions, inefficient and inadequate agricultural technology and policies, and ignorance.

"Malnutrition adversely affects mental development, physical development, productivity, the span of working years--all of which significantly influence the economic potential of man." (Allan Berg, 1973)

EFFORTS TO PROVIDE

In 1968, a symposium was convened by the Rockefeller Foundation to discuss "Strategy for the Conquest of Hunger." At that time it was asked:

"How much has science done for the many other tropical food crops, the legumes, the other cereals, and for fruits and vegetables...?" (Sterling Wortman, 1968)

As if in response to Dr. Wortman's query, representatives of six Asian governments, the U.S. Agency for International Development, and the Asian Development Bank formed the Asian Vegetable Research and Development Center (AVRDC) in 1971. Research activities were initiated in the fall of 1972.

From more than 100 crops that are considered to be vegetables[+], the following six were selected for initial research and improvement, viz., soybean (*Glycine max*), mungbean (*Vigna radiata*), tomato (*Lycopersicon esculentum*), Chinese cabbage (*Brassica pekinensis*), sweet potato (*Ipomoea batatas*), and white potato (*Solanum tuberosum*).

Thus, located in the center of Taiwan's southern coastal plain and surrounded by some of the most productive and hardest working small farmers in the world, an equally diligent (and small) international group of scientists has been charged with the formidable task of developing appropriate technologies for increasing and improving vegetable production in the hot, humid lowland tropics.

Most tropical countries have traditionally depended upon vegetable producers in the highlands to supply their urban produce markets. However, the recent rapid growth of urban centers has outdistanced the production capacity of such limited highland areas, thereby resulting in shortages and high prices.

It is not surprising that both production and consumption levels of vegetables are so low when one considers the relatively meager research efforts that have been devoted to the improvement of such crops in the tropics. Until recently, much of the research on the crops selected by AVRDC had been conducted in the temperate regions, and the resulting innovations have generally been more appropriate for the farmers of North America, Western Europe, and Japan than for their counterparts in the tropics. Many agricultural innovations and policies from the temperate zones have been introduced into the densely populated tropical regions without adequate adaptation to local conditions. Such imports have generally resulted in failure and the further negative conditioning of small farmers' attitudes toward 'modern agriculture'.

As one of the international agricultural research and training centers (Fig. 1) charged with developing suitable technologies for tropical farmers, AVRDC is part of an important effort to correct this technological deficiency. AVRDC's location--just below the Tropic of Cancer--enables our scientists to

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[+]There is, unfortunately, no all inclusive or universally acceptable definition for the term *vegetable*. Our use of the term is in the broadest sense as indicated by the nature of our six *vegetable* crops, i.e., food legumes, traditional horticultural crops, and root and tuber crops.

test our crops under hot, wet tropical conditions during the summer and multiply seed stock, advance generations, and evaluate breeding materials for optimum yield potential during the cool, dry winter season. In addition, because of the local development of diverse cropping patterns, our scientists and trainees are able to observe and study the role of AVRDC's crops within different multiple cropping systems on neighboring farms.

We at AVRDC would like to acquaint you not only with some of our accomplishments during the past year in this brief progress report, but also with the challenges that we face along with our many colleagues in the effort to produce more and better food for the world's billions.

VEGETABLES FOR BETTER DIETS AND HIGHER RURAL INCOME

"With one fifth of the world's arable land, the Asian and Pacific region is home to more than a half of the world's people. According to conservative estimates, nearly 30% of the region's population is malnourished and suffering from protein deficiency." (UNDP, 1975)

The most economic sources of plant protein, vitamins, minerals, and fiber are the legumes and vegetables. In Asia, AVRDC's area of special emphasis, rice is the principal food staple that provides most of the calories consumed. AVRDC's six crops are effective nutritional supplements to a rice diet (Table 1). particularly in supplying protein; iron; calcium, vitamins A, B_1, B_2, and C; and niacin, which are generally the nutrients most lacking in tropical diets.

Table 1. Nutritional contributions of AVRDC's six crops towards balancing a rice diet.[a]

Crop (per 100 g)	% H_2O	Fiber (g)	Energy (Cal)	Protein (g)	Iron (mg)	Calcium (mg)	Vitamin A I.U.	Vitamin B_1 (mg)	Vitamin B_2 (mg)	Niacin (mg)	Vitamin C (mg)
Rice	13	0.5	354	6.5	0.6	15	0	0.11	0.04	1.4	0
Soybean	8	**18.0**	325	**36.8**	**7.4**	**216**	20	**0.44**	**0.31**	**3.2**	0
Mungbean	11	1.1	320	**22.9**	**4.9**	**86**	70	**0.52**	**0.29**	**3.1**	0
Sweet potato[b]	70	0.3	113	2.3	**1.0**	**46**	**7,100**	0.08	0.05	**0.9**	**20**
White potato	67	0.1	75	2.3	0.7	7	0	0.07	0.04	**1.0**	**7**
Tomato	95	0.3	18	0.7	0.4	11	**260**	0.04	0.03	0.4	**29**
Chinese cabbage	95	0.5	15	1.9	0.7	**38**	+	**0.10**	**0.10**	0.4	**35**
Recommended nutritional balance[c]			354	7.8	2.4	83	690	0.19	0.20	2.4	7

[a]Adapted from T. C. Tung, P.C. Huang, H.C. Li, and H.L. Chen. Composition of foods used in Taiwan. Journal of the Formosan Medical Association, Vol. 60(11) pp. 973-1005, Nov 1961. [b]Orange-fleshed sweet potato roots. [c]Combined averages of recommended balance when caloric level is 354 Cal (100 g of rice) for adult men doing moderate work and 10-year-old children in Taiwan and India. "+" = Trace. ***** = significant contribution.

The eight essential amino acids, the building blocks of protein, must be properly balanced in order to supply human requirements for protein. The protein of most cereals is deficient in one or more of these amino acids. However, animal protein is not the only available source of an appropriate balance of amino acids. The same balance can be achieved by consuming the right combination of vegetable products, e.g., a proper combination of cereals and pulses (mungbeans, peas, soybeans) usually provides an adequate balance.

In a recent conference on nutrition at AVRDC, one of the participants presented data (Table 2), which compared the 1965 consumption patterns of AVRDC's crops to the projected needs of selected Asian countries for 1980. Approximately 17 and 19% of the daily caloric and protein intake per capita, respectively, were supplied by vegetables, including pulses and root crops. The total projected demand for 1980 was about 16.5 million tons more than what was produced in these countries in 1974 (Table 3).

"...improved production of vegetables, broadly defined, offers the greatest opportunity for better nutrition in the tropics today." (Munger, 1971)

Statistical data for AVRDC's crops are frequently unobtainable or grossly inadequate for many countries. Therefore, such crops are generally not accurately reflected in most gross national production and consumption estimates. Some of this is due to their very nature as either backyard or subsistence crops. However, even with that in mind, the current production and yield levels of our crops in the developing countries are far from sufficient in providing for the nutritional needs of their growing population (Table 4). Such countries, which contain nearly half of the world's population, only produced 14% of the world's sweet potato, 17% of its soybean (4% if Brazil's production is excluded), and 7% of its white potato.

Increased production of AVRDC's crops must come from higher yields as available land for vegetable production is limited and in some cases is even being reduced to make room for higher yielding, but less nutritional cereal crops. Research is vital to break through the yield barriers holding back vegetable and legume production in the tropics. Technology must also be developed to incorporate high yielding vegetables with high yielding grains in extensive multiple cropping systems to ensure both economic and appropriate nutritional returns.

In addition, both policymakers and research workers in the tropics must give more attention and higher priority to the long neglected root crops--crops that have the potential of producing more carbohydrates and are a

Table 2. Proportions of daily per capita calorie and protein intake for selected Southeast Asian countries based on consumption patterns for 1965 and projected demands for 1980.[a]

Country & year	Daily Cal/capita			Daily protein (g)/capita		
	total diet	vegetable[b]	% of total	total diet	vegetable[b]	% of total
Singapore						
1965[c]	2,454	237	10	63	10	15
1980[d]	2,912	258	9	72	11	15
Hong Kong						
1965	2,324	183	8	65	7	11
1980	2,856	219	8	78	9	11
W. Malaysia						
1965	2,225	166	8	49	7	15
1980	2,511	180	7	55	8	15
Taiwan						
1965	2,379	280	12	59	12	20
1980	2,689	251	9	71	13	18
Korea						
1965	2,421	338	14	67	12	18
1980	2,632	341	13	83	14	17
Thailand						
1965	2,226	216	10	51	7	14
1980	2,428	213	10	57	8	14
Philippines						
1965	1,895	181	10	44	4	8
1980	2,020	184	9	47	4	8
Indonesia						
1965	1,798	473	26	39	11	28
1980	1,998	481	24	43	11	26
Total						
1965	2,013	349	17	47	9	19
1980	2,212	351	16	50	10	20

[a]Adapted from material prepared by R. W. Engel for AVRDC Nutrition Conference (June 1976) from FAO's Agricultural Commodity Projection 1970 to 1980, Rome, 1971. [b]Vegetables in this table include commercial vegetables, root and tuber crops, pulses, nuts, and oilseeds. [c]Average consumption level for 1964-65-66 from FAO Food Balance Sheets. [d]Estimated demand based on price and quantity elasticities and projected income changes.

complementary source of protein, vitamins, and minerals, thereby providing nutrient components at a price that the poorer strata of society can afford. Present yields and nutritional quality of most Asian varieties of sweet potato are extremely low. However, farmers' yields in Taiwan have shown that sweet potato is capable of producing almost double the amount of calories produced by rice on a daily per hectare basis. Investigations within AVRDC's germplasm collection have indicated that the potential of breeding for high protein as well as high β-carotene content is very promising.

Table 3. Comparison of projected demand for vegetables[a] in 1980 and 1974 production levels for selected Asian countries.[b]

Country	Projections for 1980[c]			1974 domestic vegetable production[d]
	population	per capita vegetable consumption	yearly vegetable demand	
	(000,000)	(kg/yr)	(1,000 t/yr)	(1,000 t)
Singapore	2.4	104	250	13
Hong Kong	5.1	128	653	40
W. Malaysia	12.1	80	970	313
Taiwan	18.1	111	2,009	4,837[e]
Korea	41.7	195	8,123	4,122
Thailand	48.4	104	5,014	5,018
Philippines	54.5	84	4,556	1,596
Indonesia	157.1	159	24,916	14,233
Total	339.4	137	46,492	30,172

[a]Vegetables in this table include commercial vegetables, root and tuber crops, pulses, nuts, and oilseeds. [b]Adapted from material prepared by R. W. Engel for AVRDC Nutrition Conference (June 1976) from FAO's "Agricultural Commodity Projection 1970 to 1980, Rome, 1971. [c]Estimated demand based on price and quantity elasticities and projected income changes. [d]Data, except for Taiwan, from FAO Production Yearbook, 1974, vol. 28-1, Rome, 1975. [e]From Taiwan Agricultural Yearbook, 1976. Dept. of Agric. & Forestry, Provincial Government of Taiwan.

Ignorance concerning proper nutrition is by no means restricted to the tropics or even the poor. Policymakers as well as housewives need to be informed about basic nutritional requirements and how such requirements can be satisfied. In selecting the crops for AVRDC's initial research priorities, careful consideration was given to the basic nutritional needs which these crops could fulfill, and the economic opportunities that they might provide. The goals of our crop improvement efforts have been defined based on the premise that the good health of the entire population is one of the most important requisites for the building of a modern society.

Not only has the food production--and the vegetable production in particular--of the tropics lagged behind its potential and fallen far behind the growth of the area's population; but a substantial part of the population has remained unemployed, economically unproductive, and thus, too poor to purchase an adequate diet even when food is available.

Concerned governments in countries, which once exported food but are now faced with the threat of ever increasing imports, are striving to develop food policies that will keep the growth rates of food production ahead of the annual increase in population. It was suggested at the 1976 World Food Conference that such food production policies should (i) ensure adequate nutrition for the country's inhabitants' (ii) generate more employment and income; (iii) provide, where possible, surplus food products for export to obtain foreign exchange; (iv) develop food processing and distribution industries using local materials, as well as industries

Table 4. Comparison of production levels and average yields for each of AVRDC's crops among selected areas of the world in 1974.[a]

Item	Developing market economies[b]	Developed market economies[b]	Centrally planned economies[b]	World
SWEET POTATO:				
production (1,000 t)	18,137	1,758	114,330	134,225
% of world production	14	1	85	100
production per capita (kg/person)	9	2	93	34
average yield (t/ha)	3	13	9	7
SOYBEAN:[c]				
production (1,000 t)	9,804	34,120	12,879	56,803
% of world production	17	60	23	100
production per capita (kg/person)	5	46	10	14
average yield (t/ha)	1.4	1.6	0.8	1.3
DRY BEANS:[d]				
production (1,000 t)	7,790	1,883	1,784	11,458
% of world production	68	16	16	100
production per capita (kg/person)	4	3	2	3
average yield (t/ha)	0.5	0.8	0.5	0.5
TOMATO:				
production (1,000 t)	10,690	18,986	6,583	36,259
% of world production	30	52	18	100
production per capita (kg/person)	6	25	5	9
average yield (t/ha)	14	33	18	22
CABBAGE:[e]				
production (1,000 t)	2,835	7,552	3,518	13,904
% of world production	20	54	26	100
production per capita (kg/person)	2	10	3	4
average yield (t/ha)	11	24	25	19
WHITE POTATO:				
production (1,000 t)	21,406	79,297	193,020	293,724
% of world production	7	27	66	100
production per capita (kg/person)	11	106	157	75
average yield (t/ha)	9	23	12	13
Population (millions)	1,927	750	1,228	3,905
% of world population	49	19	32	100

[a]Source: FAO, Production Yearbook, 1974. Rome, 1975. [b]As defined by FAO. [c]If Brazil is excluded, the data for the developing mkt. economies would be 2.3 million t; 4% 1 kg/person; and 1.1 t/ha. [d]As defined by FAO--includes mungbean. [e]All types of cabbages, including Chinese cabbage.

utilizing by-products, in order to improve local employment opportunities; and (v) improve national self-reliance in food and agricultural raw materials and thus, ensure an available supply of such materials for local food processing industries. Without a doubt, AVRDC is ideally situated in terms of both crops and location to conduct meaningful research on the implementation of such policies.

Besides providing Asians with highly nutritious supplements to their traditional rice diet. AVRDC's crops also offer small Asian farmers opportunities to increase their incomes. These crops fit into numerous cropping patterns with rice, sugarcane, corn, etc., and are grown by small farmers in multiple cropping systems under both rainfed and irrigated conditions. The marketable surpluses produced can be channeled into urban produce markets, processing factories, and exports, thereby generating more jobs and income for rural populations.

Vegetable production is generally thought to be more labor intensive than cereal production. Thus, increased vegetable production would utilize more rural labor in addition to creating jobs in the processing, marketing, transportation, and export sectors. Multiple cropping systems involving vegetables tend to make more consistent use of labor over the year.

There is every reason to believe that a vegetable-producing rural populace will also consume vegetables, and that more nutritional diets will result in more productive and innovative farming. It can similarly be argued that a vegetable-consuming community will have lower rates of infant mortality; a development that in time will reduce family size. Hence, per capita income rises, and because this usually occurs in the poorer households, income distribution becomes more egalitarian.

RESEARCH AT AVRDC: DESCRIPTION AND PROGRESS

Given the world's need for greater vegetable production in the lowland tropics, we feel that our work at AVRDC on two vegetable legumes, two vegetable cash crops, and two root and tuber crops is an example of both what can and must be done to meet our commitment to the small farmers of the tropics.

In the ensuing discussion, we present each of our six crops and describe the key problems limiting its production in the tropics. AVRDC's crop improvement objectives and strategies are also outlined and followed by a brief summary of research highlights for 1975.

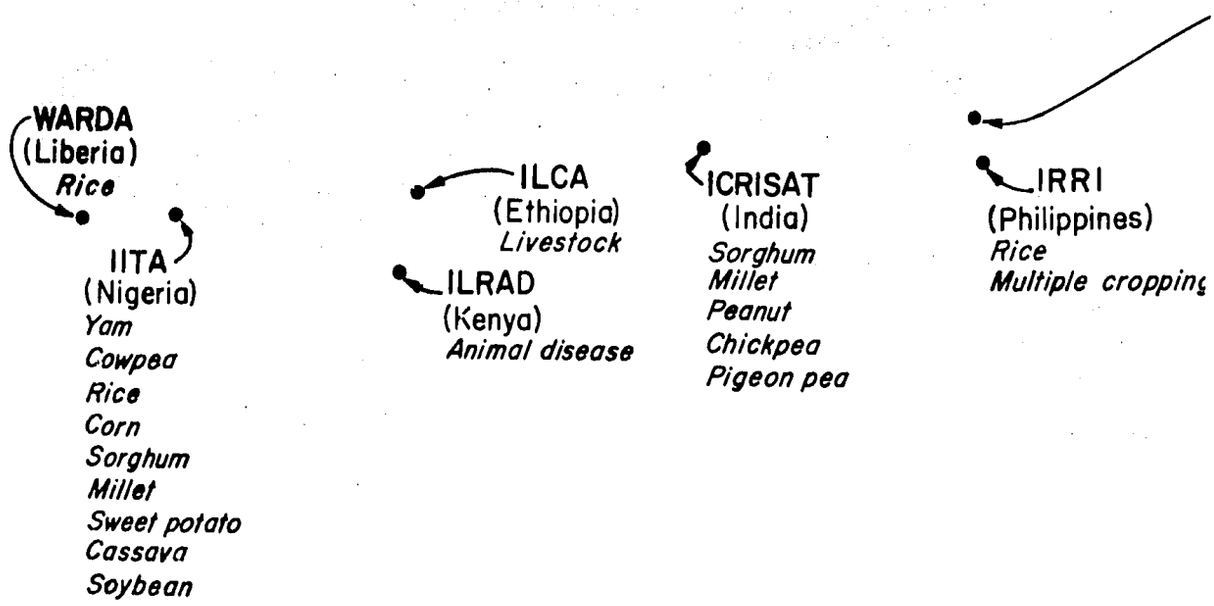
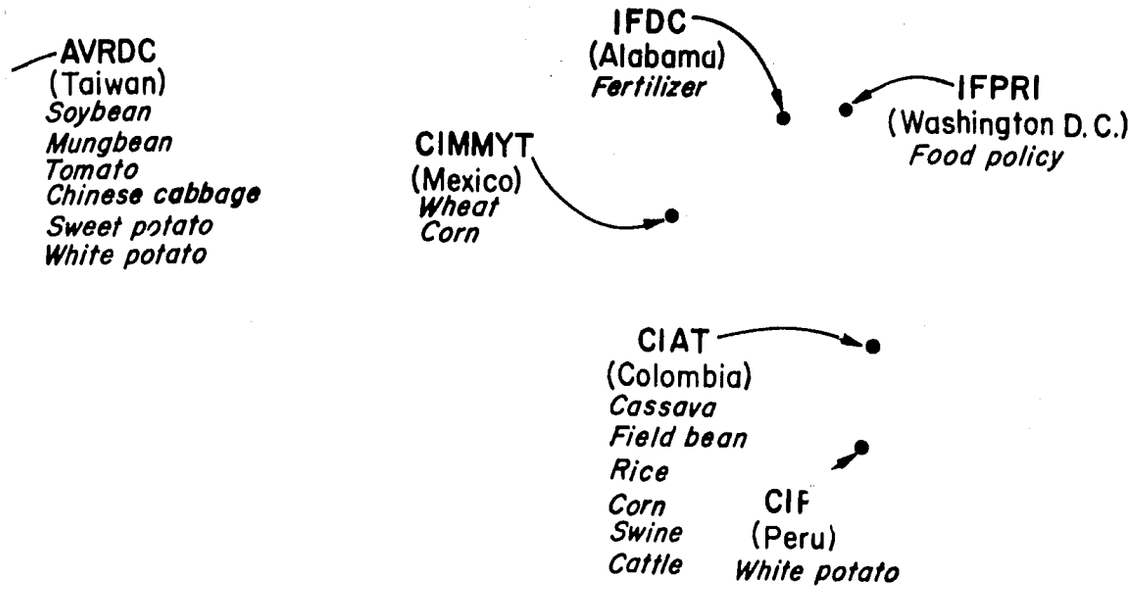


Fig. 1. International Agricultural Research and Training Centers.


AVRDC
(Taiwan)
Soybean
Mungbean
Tomato
Chinese cabbage
Sweet potato
White potato
IFDC
(Alabama)
Fertilizer
IFPRI
(Washington D. C.)
Food policy
CIMMYT
(Mexico)
Wheat
Corn
CIAT
(Colombia)
Cassava
Field bean
Rice
Corn
Swine
Cattle
CIF
(Peru)
White potato

The golden pearl.

AT A GLANCE:

Soybean production and yields in the tropics, 1974.[a]

Country	Production	Yield
	(1,000 t)	(t/ha)
Indonesia	550	0.8
Nigeria	65	0.4
Philippines	1	0.8
Thailand	115	1.1
Uganda	3	0.6

[a]Source: FAO, Production Yearbook, 1974.

Soybean [*Glycine max* (L.) Merrill], one of the world's oldest cultivated crops, has been given recent prominence because of its broad utility and versatility for both human and animal nutrition, effect on soil fertility, and industrial usefulness. Besides being an important source of protein meal and vegetable oil, the immature beans can be eaten as a green vegetable, and the dried bean is consumed whole, split, sprouted, or prepared in a variety of processed forms such as bean curd, bean paste, soy sauce, and beverages. It is not widely known, but young soybean leaves are also edible. Soybean has been a major food source in Eastern Asia for thousands of years, contributing to a generally balanced diet.

In developed countries, the protein is generally used as a livestock or poultry feed, although soy flour and more sophisticated soy proteins are being used increasingly as meat extenders and as components of a wide variety of "manufactured" foods.

Soybean has also become extremely important in economic terms. It has become the leading export of the United States, surpassing not only traditional agricultural exports such as wheat and corn, but also such high technology items as computers and jet aircraft. Yet since 1950, soybean yields have increased less than 30%, whereas corn yields have increased by 140% in the U.S.A. Thus, the world obtains more soybeans only by planting more area to soybean. For most countries including the United States, it will become increasingly difficult to make more land available for soybean. An inability to achieve a major breakthrough in soybean yields may create serious global supply problems for this most promising source of vegetable protein.

Soybean is not well known in most parts of the tropics. In many regions, the acceptance of soybean as a food crop by indigenous populations has not been successful. Varieties and cultural techniques developed in the temperate zones have generally not been adapted to the humid, lowland tropics. In addition, little attention has been given to developing locally acceptable uses for soybean. Thus, in many tropical countries, demand has been limited and production has remained at relatively low levels. It has been reported that the major obstacle to increased soybean production in the tropics is lack of markets and understanding of its cultivation and utilization.

AVRDC's international Board of Directors are briefed in the field on the progress of AVRDC's soybean work.

Soybean is sensitive to photoperiod, a characteristic which limits its area of adaptation and affects its time of maturity. Most soybean cultivars, adapted to production under U.S. conditions, flower soon after emergence and require careful management to produce satisfactory yields when planted in the tropics. Through massive screenings of its germplasm, AVRDC is identifying cultivars whose "biological clocks" are less sensitive to changes in photoperiod. Such cultivars will be used in the development of prototypes with

Soybean cultivars pass through numerous tests at AVRDC in order to determine their sensitivity to photoperiod. Those which are consistently insensitive to different day lengths are then included in our breeding program.

flexible planting dates, which local plant breeders can then refine and modify specifically for local growing conditions.

Soybean production and yields are greatly reduced by disease and insect problems in the humid tropics. Of particular importance is soybean rust caused by *Phakopsora pachyrhizi*, which has reduced soybean yield by 68% in AVRDC experimental fields (Table 5). This disease is prevalent in the Asian tropics and although generally unknown in the Western Hemisphere, this fungal pathogen was reported to be in Central America. Recently unconfirmed reports have placed it in Eastern Africa. There is considerable concern among soybean growers in both the U.S.A. and Brazil, because all U.S. varieties were susceptible to rust in screenings at AVRDC and else where in Asia. We have concentrated our efforts accordingly and have made progress in understanding and controlling soybean rust.

Soybean rust symptoms are usually evident on the leaves 10 days after inoculation.

Table 5. Yield and 100-seed weight of TK 5 in plots sprayed with Dithane M-45 and those without fungicidal protection in the rust nursery; 1975, AVRDC.[a]

Yield[b]		100-seed (wt)		Reduction in	
protected[c]	not protected[d]	protected	not protected	yield	100-seed (wt)
(t/ha)		(g)		(%)	
2.2	0.7	18.5	12.5	68	32
LSD 5%	1.1		5.1		

[a]TK 5 was sown Sep 18 in the rust nursery; population density: 400,000 plants/ha. [b]Yield calculated from 42 m² plots; 3 replications. [c]Protected with Dithane M-45 (2 kg a.i./ha) on a weekly spray schedule. [d]Not protected with fungicide.

Other diseases which concern us at AVRDC are soybean mosaic virus, purple seed stain (*Cercospora kikuchii*), downy mildew (*Peronospora manshurica*), and root-knot nematodes (*Meloidogyne* sp.). Sources of resistance to each of these diseases have been obtained and identified and are being used in our breeding program.

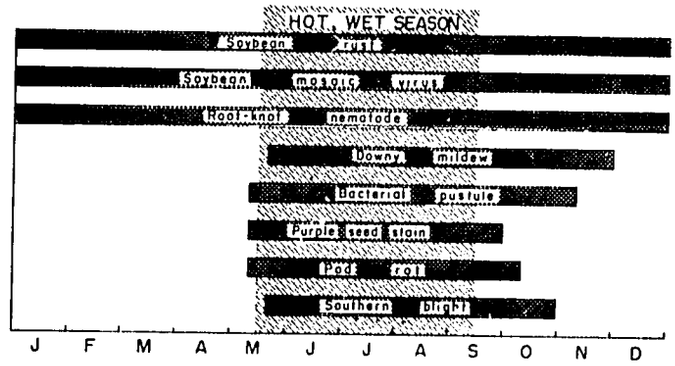


Fig. 2. Epiphytotic conditions of diseases attacking soybean during the year in Southern Taiwan.

Soybean plants are attacked by a number of foliar-feeding insects such as beanflies (*Melanagromyza* sp.), southern green stink bug (*Nezara viridula*), spider mites (*Tetanychus* sp.), leafhoppers (*Empoasca* sp.), and various leaf-feeding beetles and caterpillars. The germplasm is being systematically screened to identify cultivars that are less damaged by these pests. In addition, chemical insecticides and biological control agents are being carefully evaluated for effective and economical pest control.

The larvae of the small beanfly can seriously damage soybean plants.

Low soybean yields in the tropics are generally associated with low levels of soil fertility, inadequate population densities, and ineffective nodulation. Intensive work is under way at AVRDC to understand and correct these deficiencies.

Last but not least, more needs to be known from the socioeconomic, or farmer's perspective about the production, distribution, and utilization of soybean in the tropics. The accumlation and analysis of such data is in itself an immense, but essential task.

1975 Soybean Highlights. Soybean production in Taiwan was surveyed and analyzed to assist us in understanding production methods, conditions, costs, and problems from a producer's perspective (Table 6). This Taiwan survey will serve as a baseline for future regional surveys of soybean production and marketing in Asia.

Table 6. Characteristics of soybean production in Taiwan according to location and cultural method; 1974-1975, Taiwan.

Category	Farm size (A)		Field size (B)		B/A[1]	Yield	
	mean	range	mean	range		mean	range
	(ha)				(%)	(t/ha)	
Location:							
Pingtung (N=81)	1.2	0.1- 5.8	0.8	0.1-3.4	67	1.8	0.4-2.7
Kaohsiung (N=29)	0.6	0.1- 1.6	0.4	0.1-1.3	69	1.7	1.1-2.5
Hualien (N=28)	3.4	0.9-28.2	0.7	0.2-2.8	21	1.0	0.1-2.1
Cultural method:							
NTRS[2] (N=100)	1.0	0.1- 5.8	0.7	0.1-3.4	70	1.7	0.4-2.7
Tillage - lowland (N=10)	1.7	0.4- 3.5	0.9	0.1-2.4	53	2.1	1.9-2.5
- upland (N=28)	3.4	0.9-28.2	0.7	0.2-2.8	21	1.0	0.1-2.1
Total (N=134)	1.5	0.1-28.2	0.7	0.1-3.4	46	1.6	0.1-2.7

[1]This percentage indicates the relative importance of soybean to the farmer as the percentage of his total farm size (A) planted in soybean (B) for the sampling period. [2]NTRS = no-tillage, rice-stubble cultural method.

Contributions from seven countries added 3,960 accessions to AVRDC's *Glycine* sp. germplasm collection, bringing the total to 9,093 at the end of 1975.

During the year, we distributed seed samples of 205 cultivars and 1,151 segregating populations to 49 individuals in 29 countries.

A total of 1,309 successful crosses were made involving 349 single, double, triple, and back cross combinations. These crosses were made to combine high yield potential with insensitivity to variations in photoperiod and to incorporate resistance to various diseases attacking soybean in the tropics.

Twenty-five elite selections were tested for yield in Taiwan and the Philippines. Selections from KS 628 and KS 535 yielded more than 4 t/ha at AVRDC. Five entries which produced more than 3 t/ha in 1974 did equally well in 1975. In a preliminary yield trial of 86 F_4 breeding lines, 20 entries had yields greater than 3 t/ha.

The combination of plant height and the increase in plant height after flowering was selected as a criterion in screening for high yield potential.

Nine soybean cultivars were identified as moderately resistant to soybean rust after artificial inoculation in a field screening of 1,080 entries.

A soybean rust rating system was developed and adopted by soybean rust research workers at an international soybean conference in Thailand.

Varieties that were resistant to races of *P. pachyrhizi* in India and Australia were tested in both the field and laboratory at AVRDC and proved to be susceptible to the local races, which seem to be more virulent.

Results from repeated experiments confirmed that soybean rust is not a seedborne disease.

A biweekly spraying of Dithane M-45 effectively reduced yield loss due to soybean rust if begun 15 days after planting.

In an advanced field screening of 136 entries which were artificially inoculated, 25 cultivars were highly resistant to purple seed stain.

Ten resistant soybean cultivars were selected from a preliminary screening of 23 entries in a field heavily infested with root-knot nematodes.

A physiological race of *Peronospora manshurica*, the causal organism of downy mildew on soybean, was identified by using standard race differential hosts.

Of 187 soybean cultivars screened for reaction to beanfly attack in the fall, seven were less preferred. Among 11 legume species evaluated for comparative beanfly infestation rates, soybean was one of the three most preferred hosts (Table 7). Dimethoate, carbofuran, mephosfolan, surecide, and oxamyl were the most effective insecticides for controlling beanfly in soybean.

Table 7. Comparative severity of beanfly attack on 11 different legumes; 1975, AVRDC.[a]

Common name	Scientific name	Plants damaged		Infestation levels		% of plants infested by beanfly species	
		%	arcsine transformation	no. of immature beanflies/plant	square root transformation	M. phaseoli	M. sojae
Garden pea	P. sativum	9	9	0.1	1.0	0	100
Rice bean	V. umbellata	10	14	0.1	1.0	100	0
Black gram	V. mungo	29	30	0.4	1.2	100	0
Mungbean[b]	V. radiata	49	44	0.4	1.2	100	0
Cowpea	V. unguiculata	52	48	0.6	1.3	100	0
Adzuki bean	V. angularis	60	51	0.8	1.3	98	2
Asparagus bean	V. sesquipedalis	79	67	1.0	1.4	100	0
Tepary bean	Ph. acutifolius	81	66	1.8	1.7	100	0
Soybean[c]	G. max	81	69	1.0	1.4	58	42
Lima bean	Ph. lunatus	82	71	1.6	1.6	57	3
Snap bean	Ph. vulgaris	91	84	4.0	2.2	100	0
	Mean	60	53	1.3	1.5		
	LSD 1%		31		0.3		

[a]Sown Jul 10; 50-plants/plot; 4 replications; 10-plant samples were taken Jul 28, and Aug 5. [b]Mungbean cultivar CES 87-17.
[c]Soybean cultivar Shih-Shih.

Four species of hymenopterous parasites of beanfly were observed at AVRDC with the most prevalent being *Plutarchia* sp. Local parasite population peaks approached 50% in beanfly puparia in April and July. Two beanfly parasites, *Opius importatus* and *O. phaseoli* were introduced from Hawaii for propagation and future release in Taiwan.

An air suction trap and an insect emergence chamber were designed and constructed to help evaluate seasonal population dynamics of small flying insects and to produce large numbers of adult beanflies for parasitism and resistance studies, respectively.

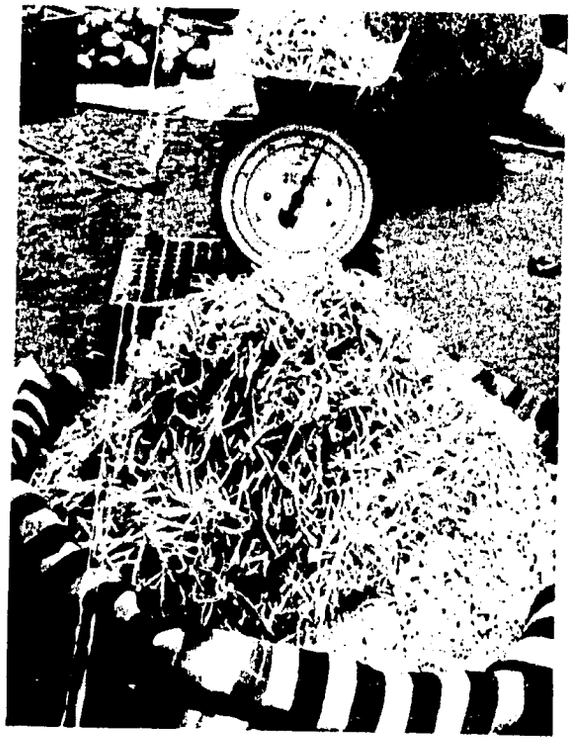
An air suction trap is used to obtain samples of small flying insects at AVRDC.

Alachlor, applied once at 2 kg/ha as a preemergence herbicide, controlled annual grasses and some broadleaf weeds in soybean plots.

In a greenhouse experiment involving soils of different fertility, application of nitrogen caused significant increases in both dry matter and pod number for all tested soils. In the less fertile soils, nitrogen also increased nodule number and size.

Soybean plants grown in pots containing calcareous soil varied greatly in yield and their utilization rates of applied nitrogen, depending upon the nitrogen sources used. Ammonium phosphate was the most effective; ammonium sulfate, ammonium nitrate, and urea were intermediate; and sodium nitrate had the least effect. These results were related chiefly to the speed of ammonium release, salt concentration in the soil, and soil pH.

Sprouts of energy.



AT A GLANCE:

Mungbean production and yields in the tropics, 1974.[a]

Country	Production	Yield
	(1,000 t)	(t/ha)
Bangladesh	14	0.8
India	494	0.4
Indonesia	17	0.6
Philippines	16	0.4
Sri Lanka	6	0.6
Taiwan	3	0.7
Thailand	190	0.8

[a]Data from country reports submitted to FAO and IAEA Regional Legume Seminar, Sri Lanka, Dec 1975.

Mungbean [*Vigna radiata* (L.) Wilczek] is an important pulse crop throughout Southeast Asia and particularly on the Indian subcontinent. This popular and ancient crop is especially esteemed as an excellent source of protein and for its high digestibility and freedom from the flatulent effects associated with other pulses. Mungbeans are often fed to babies, convalescents, and the elderly, or used when ending a long fasting period in various societies.

Mungbean, or green gram, is prepared as a dried pulse by either splitting or eating the whole bean after cooking. It is also made into a soup of dahl (porridge) and eaten with rice. bean sprouts, noodles, green beans, and bean cake are other forms of preparing mungbean.

Although generally well known in the Asian tropics, farmers' yields ranging from 380 to 660 kg/ha in India and Taiwan, respectively, reflect the present state of mungbean production in the tropics.

Indeed, little is actually known or understood about this semi-domesticated crop because it has received relatively little research attention. AVRDC has benefitted from some of the pioneering work done in India, the Philippines, and the United States, especially in amassing a germplasm collection, which at the end of 1975 contained almost 4,000 entries.

The mungbean plant is an undisciplined producer. Yields of he same variety will vary widely depending on season, environment, etc. Such uncertainty makes it difficult for a

farmer to risk his limited land, capital, and labor on mungbean production. We are, therefore, striving to develop varieties with stable, uniform yields because mungbean presently requires costly multiple harvests. We are also seeking varieties that will make more efficient use of available solar energy and soil nutrients and that are resistant to disease and insect attack.

Current varieties of mungbean require from 5 to pickings as the pods do not mature at the same time. Thus, AVRDC scientists are developing plant types with more uniform maturity.

For mungbean, even a relatively short (70 days) growing season does not allow it to escape severe disease attack. *Cercospora* leaf spot (*Cercospora canescens*) can reduce yields of unprotected mungbean by 47% during the warm, wet season. Powdery mildew (*Erysiphe polygoni*) is a severe problem during the cool, dry season. However, the unlucky mungbean may not survive long enough for either of these diseases to be of major concern as the seedlings often succumb to a combined attack of root rot fungi (*Fusarium solani* f. sp. *phaseoli*, *Pythium* sp., and *Rhizoctonia solani*) and root-knot nematodes. Sources of resistance to these and other less important diseases are being identified by screening our *Vigna* sp. germplasm.

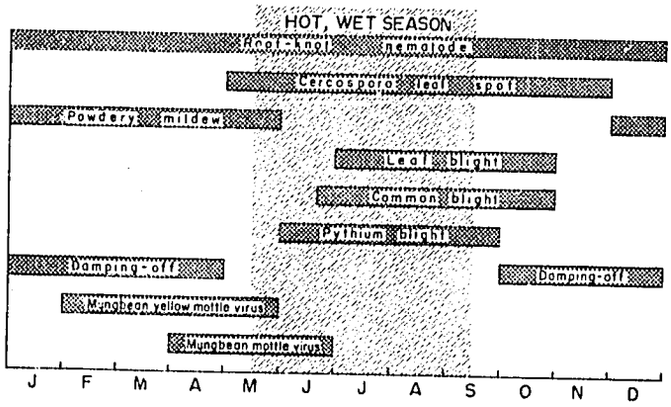


Fig. 3. Epiphytotic conditions of diseases attacking mungbean during the year in Southern Taiwan.

Mungbean is very susceptible to virus diseases, particularly on the Indian subcontinent, where a large screening of AVRDC germplasm and breeding lines was devastated by virus. The survivors were returned to AVRDC to be included in our breeding programs, and subsequent generations will be repeatedly tested in India and Sri Lanka. At AVRDC, mungbean mottle virus has caused reductions in mungbean yield as high as 79%.

Mungbean leaves with the characteristic symptoms of mungbean mottle virus, which can seriously limit mungbean yields.

Similar to soybean, mungbean is attacked by *Melanagromyza* sp. beanflies, whose larvae after hatching in the leaves burrow through the petioles and stems, killing young seedlings and damaging mature plants.

Another very important pest of mungbean in Asia is a weevil (*Callosbruchus chinensis*), which sometimes attacks the beans in the field, but principally is a storage pest. Traditional and modern methods of protecting stored beans from weevil infestation are being explored. *Heliothis* sp. and other pod borers also severely damage mungbean.

Farm-level production and marketing data are also essential, but difficult to obtain for mungbean in the tropics because of the limited attention this crop has received. Existing data usually present problems of comparison.

Weevils riddling mungbean seeds.

1975 Mungbean Highlights. To learn more about mungbean, particularly from the farmer's perspective, our agricultural economists interviewed 160 farmers, 16 farmers' association staffs, 10 seed store owners, 13 pesticide shop clerks, 4 importers, and 3 processors in Taiwan. Preliminary analysis of the data indicates that Taiwan generally imports more mungbean from Thailand and Iraq than is produced locally. Mungbean is usually sown in small plots and plays a very small role in the cropping systems of local farmers. Reasons for growing mungbean included seasonal suitability, short rowth duration, income or consumption value, and soil fertility improvement. Major costs were incurred by labor for multiple harvests and in 1975 the major problem was damage from heavy rains.

Yield trials of 20 elite cultivars were conducted in the spring, summer, and fall seasons at AVRDC. Several entries yielded as high as 1.6 to 2.1 t/ha, but such yields varied with each season. The Philippine line PHLV 18, however, had an average yield of 1.8 t/ha and was a relatively stable yielder (Fig. 4). This line also produced 75% of its yield at 66 and 75 days after sowing in the summer and fall experiments, respectively.

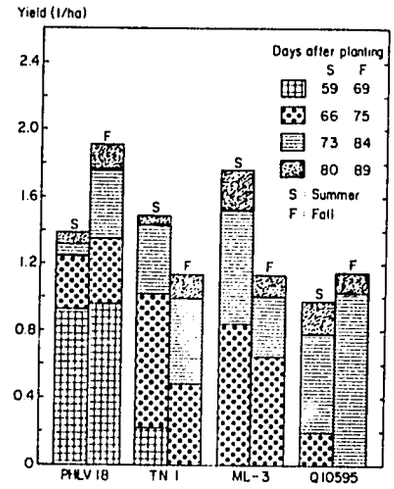


Fig. 4. Proportions of total yield harvested at 4 different dates in two trials of four mungbean cultivars.

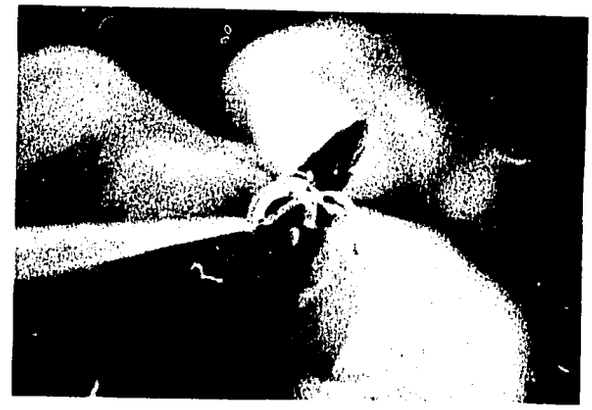
The Philippine line PHLV 18 was identified in a series of yield trials as a high, stable producer.

Significantly negative correlations were found between seed size and the number of pods per plant, yield and the number of days to first flowering, and yield and plant height (i.e., plants more than 60 cm tall produced the lowest yields, especially in spring and fall trials).

Physiologists demonstrated that the growth rate of mungbean was very slow during the inital stage (up to 35 days after sowing) regardless of variety or population density. At flowering, however, growth analysis, dry matter partitioning experiments, defoliation, and ^{14}C translocation of assimilates indicated that the higher yielding cultivars translocated a higher percentage of photosynthate to reproductive organs than the other entries.

In addition, specific leaf weight (i.e., leaf weight per unit leaf area) was positively correlated with both yield and RuDP carboxylase activity. A test for the latter may be used as a selection criterion for high yield potential.

Female mungbean flower being prepared for pollination as part of AVRDC's mungbean breeding program.



More than 400 crosses were made to combine resistance to several diseases with high yield and desirable plant type.

Ten mungbean cultivars were resistant to *Cercospora* leaf spot. Another six cultivars were resistant to attack from *Rhizoctonia* sp.,*Pythium* sp., and *Fusarium* sp. in a root disease nursery.

A previously unknown disease attacking mungbean crops at AVRDC was identified as mungbean leaf blight caused by *Thanatephoras cuccumeris*.

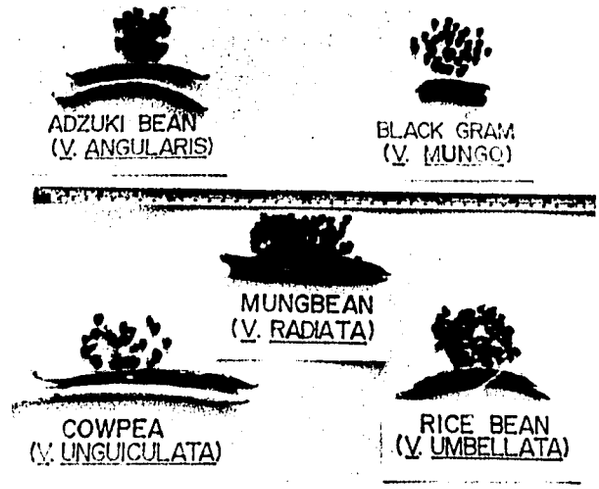
In screenings of 100 cultivars in Taiwan, Thailand, and the Philippines for beanfly nonpreference, one cultivar, LM 196 (AVRDC Acc. 2500), consistently ranked among the least infested. Adzuki bean was most severely infested by beanfly, whereas black gram, mungbean, cowpea, and ricebean (in that order) were less infested.

Successful beanfly control in mungbean was attained by applying carbofuran granules at 2 kg a.i./ha to the soil at planting or by spraying hostathion weekly at 0.25 kg a.i./ha beginning shortly after germination.

The usefulness of such traditional methods as applying peanut oil or soybean oil to prevent severe weevil infestations in stored mungbean was verified. Such methods did not affect seed viability.

To increase the genetic variability in mungbean, particularly resistance to disease and insect attack, mungbean was crossed with ricebean in a series of interspecific crosses using an immunosuppressant, E-amino-caproic acid (EACA). The success rate was doubled when a concentration of 100 ppm EACA was sprayed on the foliage of the seed parent.

Mungbean and four closely related Vigna species.



Preliminary cytological studies indicated that EACA treatment probably increased chromosomal pairing in meiosis of F_1 plants, although the F_1 progeny were sterile. Cytological examination of other interspecific crosses, which were made using conventional techniques, indicated that their progeny were likely to be spontaneous amphidiploids. No evident segregation was observed in the F_4 generation of the mungbean/ricebean crosses.

Interspecific crosses were also made between mungbean and black gram to introduce the latter's higher levels of methionine and resistance to pod shattering into mungbean. Both the F_4 and F_5 generations showed a wide range of segregation, and hybrid sterility decreased with generation advancement.

In management trials, soil scientists demonstrated that mungbean responded negatively to concentrations of ammonium ion when grown in water culture, and the crop management team did not find a yield response to different levels of nitrogen in two field experiments.

The chemists refined a microbiological assay to detect mungbean lines with high concentrations of sulfur-containing amino acids.

Sunshine on the vine.

AT A GLANCE:

Tomato production and yields in the tropics, 1974.[a]

Country	Production	Yield
	(1,000 t)	(t/ha)
Bangladesh	53	8
Cuba	70	6
Ghana	115	5
India	660	9
Nigeria	220	10
Philippines	105	6
Sri Lanka	7	2
Thailand	15	3
W. Malaysia	26	5

[a]Source: FAO, Production Yearbook, 1974.

Tomato (*Lycopersicon esculentum* Mill), a solanaceous fruit believed to have originated in Latin America, is one of the most popular vegetables around the world as well as one of the most important. It is generally grown in both home gardens and commercial fields. But in some areas, the demand for quality produce in the marketplace is sufficient for tomato to be economically grown in greenhouses or controlled environment facilities, particularly in the United States, Western Europe, the Middle East, and Japan. As a crop for the canning industry, it is most attractive.

Few agricultural products lend themselves to so great a variety of uses as does tomato. It can be eaten as a fresh fruit and is one of the most popular salad vegetables. Tomato is a primary ingredient in soups, pastes, catsups, sauces, pickles, and many other products. It is served raw, baked, stewed, fried, and as a sauce with various other foods.

Tomato, in addition to its high demand in the marketplace, is adaptable to rainfed cropping systems, offers the small farmer a profitable cash crop, and is an excellent source of vitamins A and C.

However, tomato production in hot, humid tropics is beset with many problems, which AVRDC scientists are trying to solve. Because of its susceptibility to disease and insect attack and its inability to set fruit under hot, humid conditions; almost no tomato is grown in the lowland tropics during the rainy season.

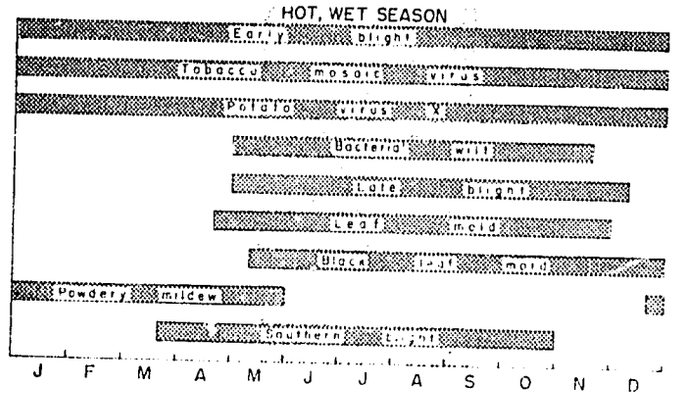


Fig. 5. Epiphytotic conditions of diseases attacking tomato during the year in Southern Taiwan.

An intensive tomato improvement effort is under way at AVRDC, seeking to combine tolerance to high temperatures and excessive moisture with resistance to bacterial wilt (*Pseudomonas solanacearum*), tobacco mosaic virus, gray leaf spot (*Stemphylium solani*), late blight (*Phytophthora infestans*), leaf mold (*Cladosporium fulvum*), and root-knot nematodes (*Meloidogyne* sp.). Careful attention is also being given to fruit quality and size, particularly with the processing industry and the transportation of the fruit in mind. Multi-disciplinary approaches are also being used to develop effective cultural practices for tomato farmers during the rainy season.

1975 Tomato Highlights. Recently, the production of tomato for the processing industry has become very important in Taiwan. Therefore, a series of economic surveys were initiated to increase our understanding of the production system. Some of the factors contributing to the significant increase in the production of tomato for processing since 1970 in Taiwan were favorable natural environment, improved technology and varieties, advantageous domestic investment policies, responsive farmers and farm-related institutions, adaptable cropping

Tomatoes in wooden crates await processing at a small cannery near AVRDC in Southern Taiwan.

systems, and favorable international markets.

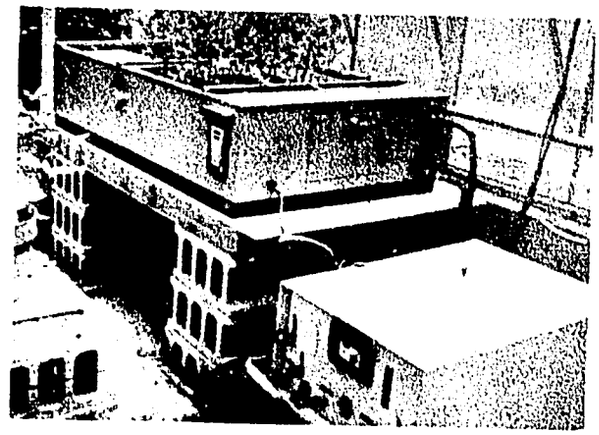
Over 95% of the *Lycopersicon* sp. germplasm collection or 3,799 entries have been screened for heat tolerance, i.e., the ability to set fruit under high temperatures. Only 31 cultivars have been selected from such screenings to serve as parental stock in our crossing program.

Seedbeds for another massive screening of AVRDC's tomato germplasm and breeding lines are prepared.

Tests conducted in both field and greenhouse confirmed that two of the heat-tolerant cultivars, which have been used extensively in our crossing work, are also able to tolerate excessive moisture --a most important attribute for the tropical tomato during summer monsoons.

Preliminary yield trials during the cool, dry season included several breeding lines with yields of 55 t/ha or more.

Tomato seedlings are tested for resistance to bacterial wilt under different soil temperature conditions in the greenhouse.



From a series of screenings involving more than 2,000 entries from our germplasm collection, 23 new cultivars with resistance to bacterial wilt were identified (Table 8). In addition, screening for resistance to bacterial wilt in both early segregating populations and advanced breeding lines resulted in a number of promising selections.

Table 8. List of tomato cultivars identified as resistant to bacterial wilt in four different tests; 1975, AVRDC.

Screening no.	AVRDC acc. no.	Varietal name	Origin
I[a]	1737	PI 250436	Czechoslovakia
I	1937	PI 263722	Puerto Rico
II[b]	1629	PI 212441	Ohio, U.S.A.
II	1822	PI 255864	Italy
II	3490	PI 341135	Maryland, U.S.A.
II	3560	PI 346890	Nigeria
II	3638	PI 357265	Yugoslavia
II	3682	PI 365902[e]	Ecuador
II	3690	PI 365914[f]	Ecuador
II	3705	PI 365930	Peru
II	3745	PI 367963	Brazil
II	3786	PI 368005	Brazil
III[c]	990	PI 129101	Colombia
III	1477	PI 200879	Afghanistan
IV[d]	751	PI 128223	Bolivia
IV	755	PI 128227	Bolivia
IV	761	PI 128233	Bolivia
IV	766	PI 128238	Bolivia
IV	791	PI 128263	Bolivia
IV	792	PI 128264	Bolivia
IV	794	PI 128266	Bolivia
IV	795	PI 128267	Bolivia
IV	798	PI 128270	Bolivia

[a]Inoculated by clipping at the seedling stage, spring, 247 entries tested. [b]Spring screening of 675 entries in bacterial wilt nursery (BWN). [c]Summer screening of 645 entries in BWN. [d]Fall screening of 575 entries in BWN. [e]L. esculentum var. cerasiforme. [f]L. pimpinellifolium.

We have also begun to incorporate resistance to tobacco mosaic virus, leaf mold, gray leaf spot, late blight, and root-knot nematodes in our most promising breeding lines. Two cultivars were identified as resistant to both leaf mold and gray leaf spot. Another five cultivars were highly resistant to root-knot nematodes.

Classical salad.

AT A GLANCE:

Cabbage[a] production and yields in the tropics, 1974.[b]

Country	Production	Yields
	(1,000 t)	(t/ha)
Bangladesh	37	7
India	420	6
Nicaragua	9	2
Philippines	53	7
Sri Lanka	13	5
Thailand	184	6
Zaire	5	3

[a]Includes all types of cabbage.
[b]Source: FAO, Production Yearbook, 1974.

As its name implies, Chinese cabbage (*Brassica pekinensis* Rupr.) is a native of Eastern Asia. Its history is long, for it is believed to have been cultivated in China before the time of Christ. From the mainland it was introduced to the adjacent islands in Pre-Columbian times. Therefore, Chinese cabbage is both well distributed and well known in the Asian tropics, but is less known elsewhere. However, it has been introduced successfully in parts of Central America, Puerto Rico, Sierra Leone, Nigeria, and the United States.

Chinese cabbage resembles head lettuce in many ways. The leaves are usually wrinkled and form heads that are less compact than those of common cabbage. The heads form rapidly, sometimes in as little as two months after transplanting, and are usually vase shaped.

Chinese cabbage has many uses. It is commonly cooked as a green, leafy vegetable or prepared in tasty soups. It can also be eaten raw as a salad. A unique dish, Kimchi, is prepared in Korea and elsewhere by fermenting Chinese cabbage and pickling it in a salt solution. Under cool conditions, it can be stored for up to three months and can also be dried for later use. Chinese cabbage is a good source of calcium and vitamins A and C. Because of its rapid growth, it is an efficient food producer.

Brassica pekinensis is a short-lived or winter annual, which is usually planted during the cool season or in the highlands due to its sensitivity to high temperatures. During the hot summer months in the lowland tropics, most varieties do not form heads and the few that do are generally irregularly shaped and soft, and sometimes have a bitter flavor. High quality Chinese cabbage is best produced at a temperature range of 15° to 20°C.

F_1 hybrids have become available to farmers in Japan, Korea, and Taiwan, and farmers in the lowlands lucky enough to escape typhoon damage have earned exceptional profits. However, hybrid seed is too expensive for many Asian farmers and the risks remain high. Yields are still considerably lower than those of winter or highland production. AVRDC scientists are in the process of creating--as has been done for common cabbage--new heat-tolerant, disease-resistant varieties of Chinese cabbage.

Chinese cabbage is vulnerable to attack from a host of disease and insects. The most serious diseases include bacterial soft rot (*Erwinia carotovora*), downy mildew (*Peronospora parasitica*), and turnip mosaic virus. Varieties with combined resistance to all three diseases are being developed.

Soft rot is a bacterial disease which severely limits Chinese cabbage production in the tropics.

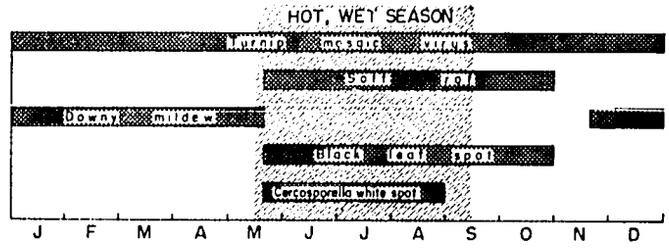


Fig. 6. Epiphytotic conditions of diseases attacking Chinese cabbage during the year in Southern Taiwan.

Current production of Chinese cabbage in the tropics generally requires large doses of insecticides to prevent the crop from being consumed by insect pests, yet such protection poses an ever increasing risk to the human consumer as insecticides are often incorrectly or carelessly applied.

Among the most damaging pests of Chinese cabbage in tropical Asia are the diamondback moth (*Plutella xylostella*), cabbage butterfly (*Pieris rapae*), and cabbage looper (*Trichoplusia ni*). All three of these lepidopterous species eat the foliage while in the

larval stage and contaminate the plant with their feces. Aphids (*Rhopalosphium pseudobrassicae*) may also building up enormous populations on Chinese cabbage, resulting in wilting and even the early death of the plant. Their numerous bodies and the sooty mold that grows on their excreta also badly fouls the plants.

AVRDC scientists are screening the germplasm for genotypes that are less preferred by the various pests. At the same time, promising chemical as well as biological controls are being evaluated for effectiveness.

Cultural methods are also being investigated as one means of reducing some of the environmental damage to Chinese cabbage.

Chinese cabbage was intercropped with corn by the physiologists to evaluate the effect of shading on the head formation of Chinese cabbage.

1975 Chinese Cabbage Highlights. An economic survey was conducted in Taiwan to determine the extent of Chinese cabbage production in the summer, to compare lowland production with that of the highlands and to identify the major factors affecting summer production. The net returns to the highland farmers for this particular season were about $180 to $200/0.1 ha per crop, whereas the lowland farmers realized no net return for their efforts. The interviewed farmers reported such problems as shortage of labor, crop damage due to diseases and insect pests, expensive chemical inputs, damage from heavy summer rains and strong winds, and low tolerance to high temperatures. The majority of these farmers were particularly interested in testing new varieties of Chinese cabbage, especially those with heat tolerance.

From our *Brassica* sp. germplasm collection, which had 601 entries at the end of 1975, 69 cultivars of *B. pekinensis* have been identified as heat tolerant.

In a summer yield trial of 61 heat-tolerant entries, AVRDC Acc. 177 produced the highest yield of 8.1 t/ha and the highest mean head weight of 324 g/head. In general, all the tested cultivars matured early within 36 to 50 days after transplanting.

In contrast, the cultivar KH 3 had the highest yield of 63 t/ha as well as the highest mean head weight, 2,363 g/head, in a winter yield trial of 154 heat-sensitive entries.

Heat-tolerant cultivars were susceptible to bolting under cool conditions in previous experiments. This tendency to bolt was tested as a criterion in screening for heat-tolerant

genotypes. The vernalization treatment that caused the best separation between the heat-tolerant and heat-sensitive entries was the exposure of germinating seedlings to continuous light at 5°C for 20 days.

By treating Chinese cabbage seeds with 50 ppm of gibberellin $A_{4/7}$ for 24 hours before placing them on an agar medium for germination, our physiologists were able to identify heat-tolerant lines as those with the longer hypocotyls.

Improvement of local, heat-tolerant varieties was accomplished through recurrent selection procedures. Increases in head weight of 18 to 23% were attained after one cycle of recurrent selection.

During the year, 65 successful crosses were made including 24 that combined heat tolerance with resistance to soft rot, downy mildew, and turnip mosaic virus.

In summer screenings of 60 F_2 populations, most of the selections had dense heads two to three times larger than those usually produced by local heat-tolerant cultivars.

Also during the summer, self-pollinated lines and assortatively-mated populations, derived from selections made the previous summer, were evaluated. Only 7 of the 34 self-pollinated lines had heat-tolerant segregants, whereas 27 phenotypically uniform selections were made from the seven assortatively-mated groups.

Seed samples of 305 cultivars and 12 segregating populations were sent to cooperators in nine countries. Reports were received from scientists in Malaysia, Bangladesh, and Thailand.

Five cultivars were resistant to soft rot in a winter screening. Temperature was an important factor in the development of this disease as temperatures between 24° and 28°C were most favorable for the bacteria.

Of 365 cultivars and advanced breeding lines screened in spring, summer, and fall planting at AVRDC, nine were resistant to downy mildew. Another six cultivars were resistant to turnip mosaic virus.

In spring and fall preference tests of 127 cultivars in the field, 36 cultivars were classified as less preferred based on the comparative insect-caused damage to the plants. The insects generally preferred the entires with light colored, fragile leaves to those with dark green, rigid leaves.

Eighteen insecticide treatments were evaluated in two screenings at AVRDC. Based on insect control, average head weight, and yield; the most effective insecticides were methamidophos, acephate, naled, EPN, and phenthoate (Table 9).

A granulosis virus disease of the diamondback moth has been tested for the past two years at AVRDC as a possible biological control agent. Single and combination treatments of this granulosis virus, *Bacillus thuringiensis*, natural pyrethrin insecticides, and a pesticide extender were comparable to quinalphos in controlling the diamondback moth.

The deleterious effects of sunlight on the pathogenicity of the granulosis virus were

Table 9. The most effective insecticides for insect control in Chinese cabbage compared to untreated control, 1975, AVRDC.[a]

Insecticide treatment	Yield (kg/10 m^2)	Average head wt (kg)	No. of *P. xylostella* larvae & pupae per plant	No. of plants in 12-plant sample with >100 aphids[b] per plant
Methamidophos (50% EC)	56	1.9	0.3	1.2
Acephate (75% WP)	50	1.7	0.8	3.5
Naled (64.5% EC)	47	1.6	0	2.0
EPN (45% EC)	48	1.6	0	6.3
Phenthoate (50% EC)	37	1.3	0.8	1.0
Control	14	0.8	9.8	11.5
LSD 5%	9	0.3	4.8	

[a]Transplanted Feb 17, variety New BaWang, 6 applications of insecticide, harvested Apr 17 to 19, 4 replications. [b]*Rhopalosiphum pseudobrassicae*.

evaluated. When the duration of exposure to light increased from 4 to 60 hours, moth mortality decreased from 98 to 6%.

Rice straw mulch reduced the growth of annual grasses on Chinese cabbage beds by approximately 70%, but the growth of broadleaf weeds increased. Soil erosion during heavy rains was minimized by placing the rice straw perpendicular to the raised beds. Mulching was also helpful in reducing the incidence of soft rot and downy mildew.

A research intern from Thailand studies management techniques with Chinese cabbage at AVRDC.

Alachlor and butachlor herbicides provided the most consistent weed control and persisted less than two months in the soil. A combination of the two herbicides gave the best weed control for both direct seeded and transplanted Chinese cabbage when applied preemergence.

Herbicides are screened at AVRDC to evaluate their potential use in controlling weeds in the tropics.

Chinese cabbage utilized 65 to 70% of the applied nitrogen fertilizer in a fertilizer experiment. Yield indices in plots not treated with nitrogen, phosphorous, or potassium were respectively 60%, 85%, and 90% of those that were treated. Application of a borax solution increased yield by more than 30% in a field experiment.

The people's root.

AT A GLANCE:

Sweet potato production and yields in the tropics, 1974.[a]

Country	Production	Yield
	(1,000 t)	(t/ha)
Bangladesh	637	10
Cameroon	550	4
Cuba	245	4
Ethiopia	265	4
Haiti	91	5
India	1,800	8
Indonesia	2,180	6
Papua New Guinea	400	4
Philippines	640	5
Sri Lanka	95	4
Sudan	495	4

[a]Source: FAO, Production Yearbook, 1974.

The people's root.

Sweet potato (*Ipomoea batatas* L.) originated in the Western Hemisphere, although the site of origin and the manner in which it was domesticated are still unknown. An early world traveler, sweet potato had reached New Guinea and New Zealand before the time of Columbus and played an important role in the colonization and welfare of the Pacific islands.

Its range has since been extended so that the species is well known throughout both temperate zones and the tropics. In 1974, the Food and Agricultural Organization estimated that approximately 84% of the world's production was on the Chinese mainland.

Sweet potato is normally a trailing vine, although climbing forms similar to typical morning-glories are known. It is a perennial crop, however, the succulent nature of its roots restricts sweet potato cultivation to relatively short growing seasons of three to six months. Unlike many root and tuber crops, sweet potato begins to store starch at a very early stage making early harvests possible. As mentioned earlier, sweet potato is one of the most efficient plants at converting the sun's energy into food.

Sweet potato is generally cultivated for the starch in its enlarged roots. However, the leaves and stem tips of its vines are frequently eaten as a highly nutritious and tasty green, leafy vegetable. Often considered a poor man's spinach, sweet potato tips have a rich protein content that helps fill the nutritional gap left by eating the low protein roots. In West Africa, sweet potato greens are particularly important, and varieties have been developed that are used only for the leaves, which are especially high in calcium and vitamin A.

Sweet potatoes being offered for sale in a market in Papua New Guinea are generally low in both β-carotene and protein. AVRDC scientists are developing breeding materials which have much higher nutritional values.

Tropical root crops such as sweet potato have traditionally been regarded as inferior foods and less worthy of attention than the cereals. Relative to the amount of research done on the staple cereals, the root crops have been seriously neglected.

Rapid urban growth in the developing countries is not only producing a new middle class with enough affluence to increase demand for the more desirable cereal foods; such growth is also resulting in an expanding mass of low income groups who place a high demand on inexpensive caloric sources.

Increased affluence would tend to increase the demand for cereals more than that for root crops. But such rises in income are being matched by increased populations. The increase in total population with proportionately fewer people remaining in the rural areas will place an increasingly heavy burden on the small farmer to produce more food. He must not only increase production to meet the demand from population growth, but also to meet the growing demand of an ever expanding, nonfood-producing urban sector. Root crops such as sweet potato are better able to meet the needs of the peasant farmer for a crop that yields well with relatively few inputs, and also meets the needs of the low income classes for an inexpensive source of calories.

Harvest time. A Taiwan farmer loads his cart with sweet potatoes, most of which will be shredded, dried, and fed to his hogs.

Several developments in the processing of root crops may also influence their future demand. Baked goods made from imported wheat flour are a staple food in many of the tropical developing countries. Sweet potato flour can be substituted for wheat flour at a rate of 15% in bread and 20 to 30% in pastries. The implementation of findings such as these may greatly increase demand for domestically produced sweet potato as well as reduce loss in foreign exchange.

Sweet potato ranks high in calories produced per hectare per day at a lower cost per calorie than cereals. Sweet potato has an amazing potential for feeding people, is relatively free from disease problems, and generally produces high and dependable yields with a minimum of costly energy-consuming inputs such as fertilizers and pesticides compared to those needed for high yields of cereals.

The sweet potato plant can use the nutrients that remain in the soil after preceding crops, and it resists environmental extremes such as drought. It can be grown in paddy fields during the dry season in many tropical countries, thus increasing the food production of hungry nations.

Perhaps sweet potato's biggest drawback is the low esteem in which it is regarded by the general population. It is a famine food, a food of last resort. Over 70% of Taiwan's large sweet potato crop is consumed by hogs. Most breeding programs have improved the starch content of sweet potato for industry with little concern for nutritional quality. However, we at AVRDC believe that sweet potato has a tremendous potential as human food and is long overdue for improvement.

AVRDC's objectives for improving sweet potato include selecting for high yield under tropical conditions, high protein content, high β-carotene (precursor for vitamin A) content, resistance to weevil (*Cylas formicarius*) infestation, dry texture, and stem tips suitable for use as a green vegetable.

Asians generally prefer a hard, dry, white-fleshed sweet potato, which is high in starch, low in protein, and contains almost no β-carotene. The sweet potato cultivars in our germplasm that came from the United States, however, are generally high yielding and contain greater amounts of protein and β-carotene. Such cultivars are generally too moist for Asians. AVRDC is crossing the U.S. varieties with Asian cultivars in an effort to develop lines that are richer in protein and β-carotene with higher yields, yet retaining the drier texture preferred locally.

Scene at a small starch factory near AVRDC where sweet potatoes are scooped on to a conveyer belt and processed for starch and other by-products.

1975 Sweet Potato Highlights. We continued to screen for genotypes which yield well under conditions of low soil fertility, minimum management, and high water stress. In a minimum input test of 194 cultivars and 495 breeding lines planted in a field which previously grew a rice crop, maximum yields were 18 and 20 t/ha for the cultivars and selections, respectively, at 155 days after planting.

AVRDC sweet potato selection 35-2 (right) outyielded the local check under minimum input conditions. This selection is also high in β-carotene and protein (7.1% dry wt).

More than 70 promising breeding lines were analyzed for protein, β-carotene, and dry matter content. Lines having poor quality were eliminated as parental materials.

Our analysis found a significant correlation (r=0.92) between the protein content of sweet potato roots and trypsin inhibitor activity (Fig. 7).

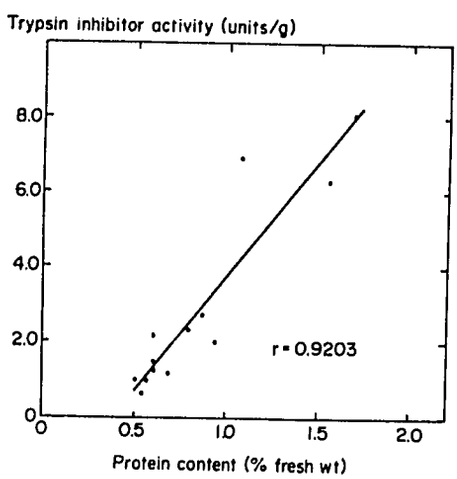


Fig. 7. Correlation between protein content and trypsin inhibitor activity in 13 sweet potato breeding lines.

A simple technique for analyzing β-carotene in flour made from sweet potato roots was developed, which replaced the laborious analysis of three separate samples per root.

Much of the exciting work in AVRDC's sweet potato program has occurred in the Nutritional Quality Laboratory in the analysis of sweet potato roots for protein and β-carotene content.

Yield trials were conducted internationally in cooperation with scientists in the Philippines, Thailand, and Bangladesh. Yields during the rainy season in the Philippines ranged from 0 to 9 t/ha. However, during the dry season, the yields ranged from 25 to 48 t/ha in 153 days. In Thailand, the highest yields of our breeding materials were about 22 t/ha. Seven AVRDC breeding lines with high β-carotene content were selected in Bangladesh.

Five sweet potato cultivars were resistant to "witches broom" or "little-leaf" disease.

From a screening in AVRDC's heavily infested weevil nursery, six relatively resistant breeding lines were selected for inclusion in our breeding program.

The screening of different insecticides for control of the sweet potato weevil gets under way at AVRDC.

In sweet potato management trials, the entomologists reported that hostathion, furadan flowable, surecide, and lannate insecticides successfully controlled the weevil.

Although varietal differences to fertilizer application levels were observed during the different seasons at AVRDC, increasing levels of nitrogen required proportionally larger levels of potassium for maximum sweet potato yields.

Tubers for tommorrow

AT A GLANCE:

White potato production and yields in the tropics, 1974.[a]

Country	Production	Yield
	(1,000 t)	(t/ha)
Bangladesh	731	9
Burma	50	5
Cameroon	40	3
Cuba	76	5
Ethiopia	170	5
India	4,626	9
Indonesia	138	4
Philippines	24	7
Sri Lanka	26	8
Thailand	10	7
Zaire	47	4

[a]Source: FAO, Production Yearbook, 1974.

White potato (*Solanum tuberosum* L.) was cultivated in the highlands of the Andes in South America over 2,000 years ago. The Spanish conquistadores brought it to Europe around 1570. It spread rather quickly throughout Europe and became a popular, easily grown staple in Ireland. When, in 1845 and 1846, a blight fungus destroyed the Irish potato crops and the resulting famine caused the death or emigration of many Irish, the crop became known as the "Irish" potato.

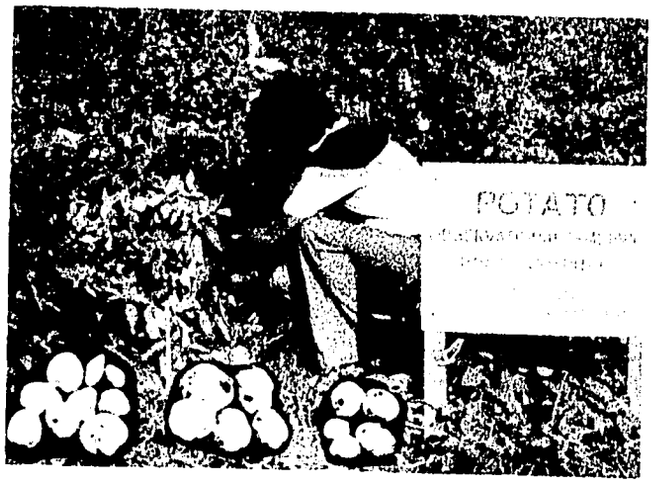
White potato has since continued its travels, and the nutritious tuber is now considered to be the fourth most important food plant of man--after the cereals, corn, and rice. In tropical Asia, white potato is still not well known, but is believed to have considerable potential for the region if a truly tropical potato could be developed. Thus AVRDC, in cooperation with the International Potato Center (CIP) in Peru, is screening the world's germplasm of tuber-bearing *Solanum* species for clones capable of tuberization under lowland tropical conditions.

White potato has been referred to as a well balanced, well packaged food. Nutritionally, it is close to sweet potato in calorie production per hectare per day and second only to soybean in protein production per hectare. In addition, white potato is an excellent source of vitamin C and the vitamin B group. Its balanced protein-calorie composition, the nutritious quality of its protein, and its relatively rapid growth makes white potato an ideal food complement to cereal crops in multiple cropping systems.

1975 White Potato Highlights. Continuing emphasis was given to germplasm introduction and screening for genotypes adaptable to hot, humid conditions.

Clones of selections made during 1974 summer trials at AVRDC were planted in a replicated trial at the Twin River Research Center (1.5 m above sea level; 7°N latitude; maximum temperatures, 31 to 37°C; mean minimum temperature, 25°C) in Davao City, Philippines. Two selections, 1282-1 and 1284-5, produced marketable yields of 22 and 20 t/ha, respectively, in 83 days. These are impressive yields when compared to the Philippine national average of 7 t/ha.

In a visit to the Twin Rivers Research Center in Davao City, Philippines, AVRDC's potato breeder, Dr. R. T. Opena, examines the performance of AVRDC breeding lines. The inserts are from the subsequent harvest.



Tuber growth rates and yields were higher for heat-sensitive clones under both high and low night temperature conditions.

Limited reciprocal grafting tests between tolerant and sensitive clones further underscored the importance of normal shoot development in the tuberization process at high temperatures.

In a carbon dioxide assimilation experiment, there was greater translocation of photosynthates to the tubers at low temperatures than at high temperatures.

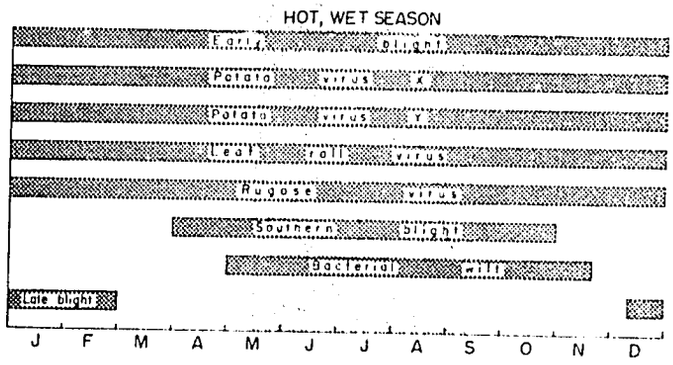
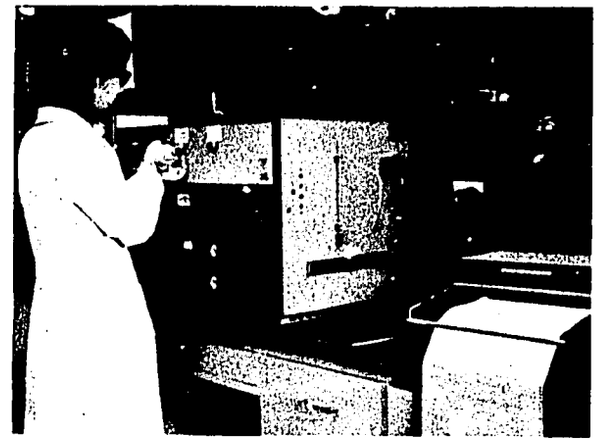


Fig. 8. Epiphytotic conditions of diseases attacking white potato during the year in Southern Taiwan.

The concentration of potassium, an element known to affect translocation processes in several plants, dramatically increased in the tuber after 48 days of growth. A gradual decline in the potassium concentration in the leaves and stem throughout the various growth stages was also observed. Potassium remained at a higher concentration (3.2%) in the dry matter of leaves taken from plants growth under high temperatures than at low temperatures (2.4%). The implications of this as a criterion in screening for heat tolerance will be studied.

Another possible criterion for use in our heat tolerance screening resulted from a study of the temperature sensitivity of the key enzymes involved in starch biosynthesis. We observed a significant reduction in sucrose synthetase levels under high temperatures. A shift to low temperatures for even one week, however, produced a marked increase in sucrose synthetase activity. Kinetic studies indicated that this enzyme is closely regulated by both uridine diphosphate and sucrose at high temperatures. Under low temperatures, however, it is only controlled by sucrose.

AVRDC's crops are also analyzed for pesticide residues to access the effect of agricultural chemicals on tropical environments.



The minimization of the breakdown of potato seedpieces under high soil temperature conditions was examined in summer field experiments involving mulching and time of cutting. Mulching accelerated emergence, reduced tuber greening, and promoted more vigorous vegetative growth, but did not significantly affect the total number of emerging plants, the stand at harvest, nor the yield. Planting whole tubers or seedpieces cut one day before planting effectively improved emergence and stand at harvest, but did not significantly increase yield.

TRAINING AND OUTREACH

AVRDC's research and production training programs offer a wide range of opportunities to vegetable research workers and production specialists throughout the tropics. The participants in AVRDC's training programs learn by doing at the side of the Center's scientific staff. Upon their return home, these participants strengthen national programs and serve as valuable cooperators in AVRDC's international activities.

Although training at AVRDC was only initiated at the end of 1974, considerable progress has been achieved. Through early 1976, 39 research, production, and student trainees from nine countries studied and worked at AVRDC (Table 10). As of February 29, 1976, AVRDC had provided 8.8 man-years of training.

A training brochure has been published which describes training at AVRDC in greater detail. Copies may be obtained by writing the Training Officer.

As an international agricultural research center, it is essential for AVRDC to develop and maintain extensive contacts throughout Southeast Asia with formal outreach programs, staff travels, exchanges of germplasm, visits of cooperators to AVRDC, and participation of AVRDC staff in international meetings.

On April 15, 1975, the Asian Development Bank made funds available for the establishment of outreach programs in Korea, the Philippines, and Thailand.

Table 10. Countries sending training participants to AVRDC through February 29, 1976.

Country	Research oriented			Production oriented	Other[a]	Total	Equivalent man years of training[b]
	interns	scholars	fellows				
	(no. of participants)						
India	1					1	0.1
Indonesia	1			2		3	0.5
Korea	2					2	0.8
Micronesia	1					1	0.1
Pakistan			1			1	0.2
Philippines	6	1		7		14	2.8
Taiwan	1			3	6	10	1.6
Thailand	5					5	0.8
U.S.A.		2				2	1.9
Total	17	3	1	12	6	39	8.8

[a]Students of local universities who spent their summer vacation at AVRDC as student trainees.
[b]As of Feb 29, 1976.

VEGETABLE RESEARCH TRAINING AT AVRDC

Mr. James A. Deutsch completed his work on the variability and inheritance of components affecting yield, nutritional value, and acceptability of Amarathus sp. and returnned to Cornell University in early 1976 to finish his Ph.D. work in Plant Breeding.

Observations are carefully recorded by Mr. Chaireng Sagwansupyakorn, a research intern from Thailand as he conducts a flower induction experiment with sweet potato.

Miss Evangelyn Ceriales, a research intern from the Philippines, irrigates her experimental plot.

At AVRDC one learns by doing. Here Mrs. Hafni Z. Syukri, a research intern from Indonesia, applies her skill in emasculating sweet potato flowers.

VEGETABLE PRODUCTION TRAINING AT AVRDC

PARTICIPANTS IN AVRDC's first Vegetable Production Course receive instruction in the classroom --

Production trainees are confronted with a challenging pre-test at the beginning of their 5-month course.

Trainees are introduced to both buffalo power,

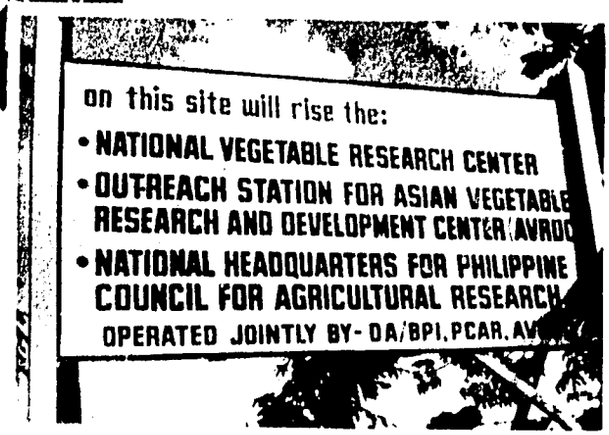
and the power tiller as part of their field experience at AVRDC.

The Korean Sub-Center, established in 1974, continued to evaluate AVRDC breeding materials under Korean conditions. The Technical Assistance Agreement was signed September 23, 1975 by the Government of the Republic of Korea, the Asian Development Bank, and AVRDC. The Bank will provide funds for a Resident Horticulturist to be stationed at the Sub-Center in Suweon and for the training of the Sub-Center's staff at AVRDC.

The Philippine Outreach Program of AVRDC was initiated in May at the Economic Garden in Los Banos with the appointment of Dr. John Hubbell. POP is jointly supervised by the Bureau of Plant Industry, the Philippine Council on Agricultural and Resources Research, and AVRDC. The Southeast Asian Center for Graduate Education in Agriculture (SEARCA) provides the necessary administrative services.

The Technical Assistance Agreement has not yet been signed with the Royal Thai Government. However, AVRDC continues to cooperate closely with Thai research workers on a scientist-to-scientist basis.

Dr. Robert L. Chandler, Jr., first director of AVRDC, addresses the dedication ceremony of AVRDC's Korean Sub-Center in 1974.

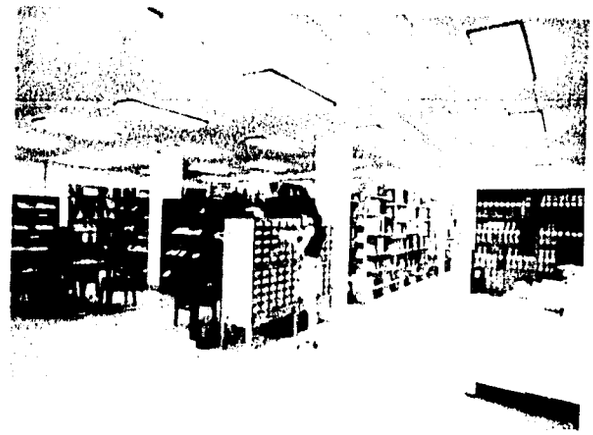


Sign announcing the site of the Philippine Outreach Program.

RESEARCH SUPPORT SERVICES

Information documentation and dissemination. The library acquired approximately 1,400 new monographic titles for a total of 3,190 titles in early 1976. During 1975 we subcribed to nearly 275 scientific journals and added 773 bound volumes to our collection, which now includes 3,865 volumes and 594 titles.

A comprehensive collection of the world's recent literature on vegetable crops and the related disciplines can be found in the AVRDC library.



The tables of contents of newly received journals are regularly photocopied and circulated among the staff. We initiated a literature search for mungbean and closely related species. More than 870 documents are believed to exist and about half are already in our collection. Similar bibliographies for our other crops will be initiated during 1976.

The Office of Information Services (OIS) further developed its capabilities to support AVRDC's research and training programs. Its functions during the year included editorial services, photographic services, artwork, offset printing, audio-visual services, visitor services, and the preparation and dissemination of information concerning AVRDC's programs and progress.

The OIS photographer at work.

The *AVRDC Annual Report for 1974* was edited, published, and distributed to over 3,500 researchers, libraries, extension workers, students, and administrators in approximately 100 countries. A general information brochure was prepared in both English and Chinese.

The reporting of research results for 1975 has been reorganized. In addition to this progress report, separate research reports have been prepared for each crop. These reports give a more detailed accounting of AVRDC's

research, training, and outreach activities and are available upon request. A detachable form is provided with this report for your use.

At the end of 1975, OIS initiated a special project to collect information and recipes on our six crops for eventual publication as an AVRDC manual on the preparation of vegetables.

This project was undertaken with the assumption that AVRDC's contribution to the improvement of diets in the tropics will not be accomplished unless people eat the vegetables AVRDC and its cooperators improve. Although there are various reasons why people do not eat certain vegetables, in many cases it may be because they do not know how to prepare the vegetables that AVRDC is improving.

The first step in meal preparation for many housewives is a visit to the local market where vegetables are carefully selected. AVRDC is preparing to help with the second step by publishing a vegetable preparation manual.

The consumption of the six AVRDC crops in different tropical countries varies both in intensity and in methods of preparation. Many methods commonly used in one country are simply not known to people in other countries or regions. Our purpose is to collect as many vegetable recipes as possible from around the world and include the simple, tasty, and nutritious ones in a manual, which can be supplemented periodically. We welcome your assistance.

A germination test of Chinese cabbage seed is conducted in the AVRDC seed lab.

Seed laboratory. A major part of AVRDC's research program todate has been the assembling of large germplasm collections for each of our six crops. To properly accommodate and maintain such collections, we have continued to expand and improve our seed storage facilities. We multiplied seed of more than 8,000 accessions for scientists at AVRDC and filled requests from our cooperators. Nearly 6,000 seed samples were distributed to 103 scientists in 30 countries. Another 80,000 packets of seed were sealed and placed in long-term storage.

Experiment farm. We continued the development of our 102-ha experimental farm in order to increase the accuracy and efficiency of our field research activities. All but 16 ha of the farm has been developed; roads, ditches, and canals account for another 16 ha. Thus, approximately 70 ha are now available for research, training, and seed multiplication. During 1975, 82% of the available land area was used.

A crop and land management committee was formed to coordinate land assignments, drainage and irrigation improvements, and soil fertility evaluations. The farm was classified on a seasonal basis according to drainage and soil fertility. Work was also initiated on the creation of windbreaks, rotation of AVRDC crops with green manure crops, and the standardization of research plots.

FINANCES

Unlike the other international agricultural research centers (all of which are supported by bilateral grants within the framework of the Consultative Group on International Agricultural Research), AVRDC is mainly supported by six countries. Expressed in U.S. dollars, funds received in 1975 totaled $1,819,979. The largest single donor was the Republic of China, which contributed $741,787. Next was the United States of America (through the Regional Economic Development Office of the U.S. Agency for International Development) with $600,000. Thailand, the Philippines, Korea, and Japan gave $75,000 each. Japan also provided the services of the Soil Scientist.

The Rockefeller Foundation provided the services of the Director and contributed a grant of $25,000 toward the mungbean improvement program.

The Sino-American Joint Commission on Rural Reconstruction (JCRR) donated $50,000 for the construction of a screen house to be used by pathologists and entomologists and the improvement of controlled environment facilities.

Support for research on improving the efficiency of fertilizer use with vegetables in the tropics was provided in two grants totaling $40,000 from the International Minerals and Chemicals Company.

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+ left during 1975

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Diosdado V. Castro, M.S., *associate training officer*
  Henry H. Lee, *training assistant*
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John N. Hubbell, Ph.D., *resident horticulturist, Philippine outreach program*

PUBLICATIONS

In addition to its annual reports, AVRDC makes available, upon request, reprints of technical papers prepared by its staff. Such papers may be obtained by detaching the form provided at the beginning of this report, marking the appropriate items, and mailing it to AVRDC. Be sure to include your complete mailing address. All AVRDC publications are free and will be sent by surface mail.

AVRDC Technical Bulletin Series:

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

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JP 1 - MacKenzie, D. R., L. Ho, T. D. Liou, Henry B. F. Wu, and E. B. Oyer. Photoperiodism of mungbean and four related species. HortScience, Vol. 10(5), Oct 1975. pp. 486-7.

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