PLANT INDUSTRY SERIES NO. 30

JCRR

BETTER CROP PRODUCTION—PROBLEMS AND SOLUTIONS

—PID Activities—

(July 1970—June 1971)

TAIPEI, TAIWAN, REPUBLIC OF CHINA
DECEMBER 1971

BETTER CROP PRODUCTION—PROBLEMS AND SOLUTIONS

— PID Activities —

July 1970 - June 1971

PLANT INDUSTRY DIVISION
JOINT COMMISSION ON RURAL RECONSTRUCTION

PREFACE

After years of service in the field of crop improvement in Taiwan, I have come to realize that a successful crop production program cannot depend on technology alone. In addition to the technical aspects of plant breeding, plant protection, plant physiology and the like, other factors also exert a decisive influence on crop production. The most important ones are the market condition, supply and demand, price and consumers' preference, and government policy.

In a changing world, crop production in Taiwan has undergone many changes. I would like to point out some of the most significant changes that have taken place here in recent years.

1) In 1963, Taiwan farmers were encouraged to grow more bananas of better quality. During that time banana growers could dispose of their produce at a fairly attractive price; thus improved farming techniques were applied extensively by the banana growers in order to boost their yield. However, this golden age of our banana trade is now a thing of the past, owing to a change in the import policy of Japan and also due to the fact that Japanese importers have shifted their regular shipping channels, which account for the decline of the banana industry of Taiwan and the loss of interest among the growers.

2) To promote hog raising in Taiwan, restrictions on the import of feed grains from abroad were lifted by the government in 1968. As a result, the production of feed crops, such as corn, sorghum and soybeans, which were formerly major winter crops, has suffered sharp decreases because the prices of imported feed grains are considerably lower than those produced locally, thus affecting the marketing of local products. This is why the acreage of winter crops has been reduced drastically in recent years.

3) The accelerated industrialization in Taiwan has also had a profound effect on crop production. The increasing flow of rural people into industry has not only created the problem of agricultural labor shortage, but also caused increases in the cost of production.

4) The average income of a farm worker is low when compared with that of an industrial worker. This has also complicated the problems of crop production in Taiwan.

In view of the above-mentioned changes in the last three years, one could well imagine that problems facing the farmers, research workers and government policy makers are numerous and diverse. One of the tasks of specialists in the Plant Industry Division is to understand and analyze these problems on the one hand, and to try their best to tackle them and improve the situation on the other. Dr. C.P. Cheng and Mr. C.K. Chao of this Division, together with research and extension workers at the district agricultural improvement stations and the Provincial Farmers' Association have mapped out a plan for the production of corn to supply a part of the local feed grain requirements. With the application of improved techniques, the unit yield of corn is expected to be substantially increased and the marketing of this product will be guaranteed at an attractive support price. It is hoped that some improvement measures could be worked out for other crops on the basis of this production program if it is carried out smoothly.

Promotion of the traditional silkworm industry with the extensive cultivation of mulberry trees was initiated in 1970, and several related projects have been carried out by a number of sponsoring agencies. In addition to JCRR financial and technical support, government funds have also been made available to this program for the first time to strengthen sericulture research and demonstrational activities. With abundant sunshine, efficient equipment and scientific know-how for worm raising and mulberry tree farming, the silkworm industry could be developed into a profitable enterprise in the near future instead of remaining a sideline occupation of farmers.

With the help of this Division during the past two years, the beekeeping industry of Taiwan has been successful in preventing the spread of bee diseases and in promoting the pollination of fruit crops and vegetable seed production, in addition to increasing the production of honey and royal jelly. Both beekeepers and farmers are now aware of the contributions bees can make to human welfare through farming.

Specialists of the Plant Industry Division have been trying to cut down the post-harvest losses of fresh fruits and vegetables due to improper handling, especially during transit and storage under the warm and humid weather conditions of Taiwan. As the known preventive measures have to be tried out through research and experiments, the projects conducted at the Taipei District Agricultural Improvement Station under the supervision of PID specialist Mr. F. W. Liu in the past two years have been rewarded with promising results. It is expected that based on the physiological response of fresh fruits and vegetables and adjustment of handling techniques plus proper grading and packaging, the loss during transit and storage can be gradually minimized when effective ways are adopted by commercial circles.

In conclusion, I would like to point out that in face of the changing social and economical structures as well as the industrial and agricultural evolutions, PID specialists are confronted with the challenge to tackle various problems pertaining to crop improvement. It is by no means an easy task to get the desired results from every program for which they are responsible. However, I firmly believe that all my colleagues are doing their utmost to attain the best performance in their work, with the cooperation of all parties concerned both inside and outside of JCRR. Here I wish to express my sincere appreciation to my colleagues and friends for their close cooperation which has made our achievements possible.

C. L. Luh
Chief
Plant Industry Division

July 1, 1971
Taipei, Taiwan
Republic of China

CONTENTS

Page

Plant Protection

Beekeeping Industry

INTEGRATED DEMONSTRATION ON IMPROVED RICE CULTIVATION TECHNIQUES IN TAIWAN

Cheng-Hwa Huang

Introduction

In the past decade, the various agencies of the Republic of China exerted every possible effort to increase food crop production in Taiwan. As a result, the total rice production in Taiwan increased from 1,641,557 M.T. of brown rice in 1953 to 2,518,014 M.T. in 1968, showing an annual average increase of more than 50,000 M.T. This remarkable achievement was mainly attributed to the increase of unit acreage yield with the average per hectare yield of rice reaching as high as 3,188 kg of brown rice in 1968. Besides irrigation water and fertilizers, the two major factors contributing to this unit acreage yield increase, the other factors were the development and extension of better varieties and seeds, adoption of improved culture practices, control of diseases and pests, good management of field operations, etc.

The application of these improved practices to increase the unit yield of rice has proved the soundness and fruitfulness of well spent research and experimental findings obtained at the various agricultural stations in recent years. Unfortunately, these improved measures have never been recommended to nor wholly adopted by the farmers in rice cultivation. With the view to evaluate the effect of combined application of all improved measures toward the increase of rice yield as well as to fully exploit the productivity of the fields, an "integrated demonstration" on improved rice cultivation techniques was, therefore, planned and carried out in the main rice producing areas on this island since the second rice crop of 1963.

The "integrated demonstration" on improved rice cultivation conducted from the 1963 second crop through the 1967 first crop at 116 townships has proved that the existing rice industry of Taiwan definitely possesses great potential for yield increase. The demonstration plots achieved an average yield increase of more than 30% and a gain of 45% more net income to the farmers. In order to popularize the integrated techniques of rice cultivation among the local farmers, an expanded program has been carried out through well-organized units since the second crop of 1967. The government also decided that this program would be managed by the Taiwan Provincial Food Bureau as a regular rice improvement project from 1969 onward.

Extent of Integrated Demonstration

The most important measures adopted in the demonstration plots as well as in the expanded program may be summarized as follows:

1. Adoption of the newly-developed leading Ponlai (*japonica*) varieties

The varieties to be used in the integrated demonstration were first recommended by rice specialists of the respective District Agricultural Improvement Stations (DAIS), based on their yield capacity, disease resistance, response to fertilizers, or any other practical criteria to meet specific local requirements. The final decision was made after discussions led by the JCRR rice specialist.

2. Raising of healthy seedlings

The seedbed was prepared in an elevated, well saturated strip. Before sowing, the seeds were treated with 1,000 times diluted Granosan solution for one to two hours, followed by thorough washing and soaking in clean water for about 48 hours. The seeding rate was 300-400 grams of dry seeds per 3.3 m^2.

During the nursery period, weeding of the seedbed was done by hand to pull out barnyard grass and off-types followed by an optimum amount of nitrogenous fertilizer application 3-5 days before transplanting. Pest control was done on a cooperative basis by dusting suitable chemicals recommended by the technicians from DAIS.

3. Careful preparation of paddy fields

The land was prepared 1-2 weeks in advance of the transplanting calculated on the harvesting date of the previous crop. Two ploughings and two harrowings were followed by the application of stable manure or compost at the time of initial ploughing. Chemical fertilizers used as basic dressing were applied just before final laddering, mixing completely with the surface soil. Then, the land was thoroughly leveled and using space-markers marked with regular lines in both directions according to the spacing desired.

4. Transplanting at optimum spacing and use of optimum number of seedlings per hill

The transplanting process at each demonstration plot with an area of 5-10 hectares during the demonstration stage was completed within three days. In the expanded program, the duration of transplanting process for each working unit covering about 20 hectares of land was less than a week. The number of seedlings transplanted per hill was four to five. The distances between rows and hills were 22.5 × 22.5 cm, 24 × 18 cm, 24 × 15 cm, or 27 × 13.5 cm respectively in different locations.

5. Proper fertilizer application

The rates of N-P-K fertilizers for the various demonstration plots were tentatively recommended by the DAIS concerned and final adjustments were made according to soil fertility in the demonstration area. The pre-demonstration analysis of soil nutrients for each demonstration area was done by the Soil Fertility Laboratory of the Taiwan Agricultural Research Institute.

The most significant feature of fertilizer application in the integrated demonstration was the increased use of phosphate and potash fertilizers. In addition, split applications of nitrogenous and potash fertilizers were also practised.

6. Coordinated intensified disease and insect pest control in the main field

All the plant protection measures adopted in the integrated demonstration followed the instructions in the "Methods of Extension of Plant Protection Techniques" pamphlet recommended by the Provincial Council on Plant Protection Techniques and revised annually by the Provincial Department of Agriculture and Forestry. The time of application and the kind of pesticides or fungicides to be used were determined and supervised by the plant pathologists and entomologists of JCRR and DAISs.

7. Better management of field operations including weeding, irrigation and drainage, roguing, etc.

Weeding and intertillage were repeated at least three times during the entire rice growing period for both crop seasons. Weeding started 10 to 20 days after transplanting and was repeated at an interval of about 7 to 15 days depending upon the crop season as well as location. Weeding was done by hand to pull out the weeds and bury them under the soil. Before and after heading, roguing was again done to pull out the barnyard grass and other off-types. Since 1970, the application of 7% of Tok granular to replace hand weeding was also recommended in the demonstration plots.

In the early growth stage of the first rice crop, when the temperature was low, deep irrigation was practised to raise the soil and water temperature; otherwise, shallow irrigation was practised. At any rate, the depth of irrigation water or the time of drainage was determined according to the water consumption by rice plants at various stages. The most important step was to drain out the field water and dry the soil for several days in late tillering stage, especially under the condition of heavy nitrogen fertilization.

Organized Farmers' Participation in Integrated Demonstration

In the demonstration stage, the farmers who had participated in the demonstration work were grouped into a team to jointly carry out field operations. A farmer experienced in rice culture was selected to be the leader of the team to relay technical instructions from the technicians of the respective DAISs to the farmers. In the expanded program, because of the large number of farmers involved in the program, the grouping was made on the village basis into a number of operating teams each with about 100 hectares of cultivated land. Each operating team was then sub-divided into working units of about 20 hectares in land area for joint effort cultivation by the farmers. Each working unit elected its own man in charge and each operating team had a farmer serving as the team leader.

Field Records

In the demonstration stage, both the DAIS supervisor and the leader of participating farmers kept their own record books to keep an account of field activities throughout the rice growing season. In addition, the same kind of field records was also kept by the DAIS supervisors, of the farmers' fields bordering the demonstration plots, for comparison.

In the expanded program of integrated demonstration, each working unit leader kept a record book of his own to record the important field operations, activities and yields of rice. Random samples were taken from each working unit to calculate the yield for that particular season. A check plot was also established for each operating team for comparison of rice yield, production cost and net profit, with the demonstration plot. The field records included: (1) number and names of varieties used; (2) dates of field operations for sowing, transplanting, weeding, fertilizer application, drainage management and harvesting; (3) amounts and methods of fertilizer applications in both the seedbeds and the main field; (4) control of diseases and insect pests and water management; and (5) yields of rice of the sampled farmers as well as yield records made by the farmers participating in program work.

Method of Determining Actual Yield

At the time of harvesting, the fresh grain yields from each sub-plot of the demonstration plot and the adjacent farmers' fields were recorded by both the farmers and the DAIS. In addition, 10 samples, each representing the fresh grain yield from an area of four *ping* (each *ping* being equal to 3.3 square meters), were taken at random from each demonstration plot and brought back to the respective stations for drying until the moisture content in the grains was reduced to around 14%. Then, the samples were weighed to calculate and determine the actual yield of dried grain. In the expanded program, the determination of rice yield followed the same procedure and method adopted during the demonstration stage, except that the samples were taken according to each working unit as a base.

Results

1. Demonstration stage

Results obtained from the demonstration stage at 116 townships from the 1963 second rice crop to the 1967 first rice crop showed that the integrated demonstration was highly successful in respect of both the actual yield increase of rice and the farmers' income. The demonstration plots achieved an average yield increase of 32.2% as compared with check plots under similar environmental conditions.

By comparing the total cost of production incurred by farmers on the demonstration plots and that incurred by those on the adjacent fields, it was found that the total cost of production on the demonstration plots was higher than that of the check plots by an average 18.7%. Among the items in the cost of production on the demonstration plots, the expenditures for pesticides and fertilizers constituted the largest part of the total. Although the total cost of production on the integrated demonstration plot was higher, it was more than offset by an average of 32.2% increase in production, thus resulting in an 11.1% reduction in comparative cost of production per every 100 kg of rice. As a result, the farmers who participated in the demonstration benefited by a large increase in net profit amounting to NT$ 4,082 or 45.2% per hectare.

The detailed comparisons of the aforesaid results are given in Tables 1 and 2.

Table 1. Rice yield and net income from integrated demonstration plots and check plots

Crop season[1]	No. of plots[2]	Rice yield (kg/ha)			Net income (NT$/ha)		
		Dem. plot	Check	% increase	Dem. plot	Check	% increase
'63-II	4	4,628.0	3,499.0	32.2	8,360.3	6,257.8	33.6
'64-I	4	6,246.0	4,693.0	33.1	15,412.0	10,816.0	42.5
'64-II	15	4,491.4	3,654.8	35.2	11,603.6	7,722.5	50.3
'65-I	15	6,058.7	4,513.7	34.2	15,578.9	10,445.2	49.2
'65-II	47	5,589.2	4,152.7	34.6	12,514.3	8,403.5	48.9
'66-I	46	5,391.7	4,144.3	30.1	12,060.8	8,311.2	45.1
'66-II	50	5,239.9	3,990.9	31.3	12,226.8	8,184.8	49.4
'67-I	39	6,207.8	4,886.7	27.0	16,898.8	11,858.5	42.5
Average		5,537.8	4,191.9	32.2	13,081.9	8,999.9	45.2

1/ I and II represent the first and second rice crops, respectively.
2/ The demonstration area for the second crop of 1963 and the first crop of 1964 was 10 hectares and that for the other crop seasons was 5 hectares.

Table 2. Production cost (NT$) in the integrated demonstration plots and check plots

Crop season	No. of plots	Cost per hectare			Cost/100 kg of rice		
		Dem. plot	Check	% increase	Dem. plot	Check	% decrease
'63-II	4	8,892	6,822	30.3	192	195	1.6
'64-I	4	9,697	7,894	22.8	155	168	8.4
'64-II	15	8,325	6,906	20.5	168	189	12.5
'65-I	15	9,329	7,890	18.2	154	175	13.6
'65-II	47	9,723	8,000	21.5	174	193	10.9
'66-I	46	9,988	8,548	16.8	185	206	11.4
'66-II	50	9,183	8,051	14.1	175	202	15.4
'67-I	39	10,025	9,213	8.8	161	188	16.7
Average		9,396	7,916	18.7	170.5	189.5	11.1

2. Expanded program

Although the expanded program of integrated demonstration was conducted in a very large area involving the participation of many farmers, the results obtained in the past five rice crops from the second crop of 1967 to the second crop of 1969 were also very encouraging. The demonstration plots achieved an average of 22.8% in yield and 41.2% of net profit increase as compared with the check plots. The detailed comparison of these results are given in Tables 3 and 4.

Table 3. Rice yield and net income from demonstration plots and check plots of the expanded program

Crop season	No. of town-ships	Area of dem. (ha)	Rice yield (kg/ha)			Net income (NT$/ha)		
			Dem. plot	Check	% increase	Dem. plot	Check	% increase
'67-II	5	2,907	5,000	4,023	24.3	12,171	8,612	41.3
'68-I	4	4,357	5,468	4,411	24.0	14,308	10,182	40.5
'68-II	7	7,724	5,277	4,305	22.6	12,490	8,587	45.5
'69-I	16	11,042	5,081	4,189	21.3	8,785	6,520	34.7
'69-II	21*	11,658	3,986	3,284	21.4	7,388	5,141	43.7
Total		37,688						
Average			4,962	4,042	22.8	11,028	7,809	41.2

* The low yield was due to typhoon damage.

Table 4. Production cost (NT$) in the demonstration plots and check plots of the expanded demonstration program

Crop season	No. of town-ships	Cost per hectare			Cost/100 kg of rice		
		Dem. plot	Check	% increase	Dem. plot	Check	% decrease
'67-II	5	9,541	8,825	8.1	190.8	219.3	14.9
'68-I	4	10,910	10,193	7.0	199.5	231.1	15.8
'68-II	7	11,008	10,415	5.7	208.6	241.9	16.0
'69-I	16	12,475	11,024	13.0	245.5	263.1	7.1
'69-II	21	11,335	10,505	7.9	284.4	319.9	12.5
Average		11,054	10,192	8.4	225.8	255.1	13.0

Significance of Integrated Demonstration

1. The integrated demonstration has proved through small scale demonstration as well as the very large scale expanded program that the existing rice industry of Taiwan definitely possesses great potentiality of yield increase.

2. The yields in the so-called low-yielding rice areas could be raised by a considerable extent through the employment of proper culture practices and the planting of improved varieties.

3. The well designed experimental findings of recent years in varietal and cultural improvements, especially those of fertilizer application techniques and plant protection, are fruitful and rewarding.

4. The integrated demonstration serves as one of the most effective means of educating Taiwan farmers on how to improve rice cultivation and how to carry out field operations through cooperation to increase unit acreage yield of rice and to reduce the cost of production.

Table 5. Major items of production cost (NT$/ha) in the integrated demonstration plots and check plots

Year		Total	Labor	Ferti.	Pest.	Seeds	Others
Demonstration:							
'64-I	Dem.	9,697	4,415	3,277	938	239	828
	Check	7,894	3,744	2,798	429	274	649
'64-II	Dem.	8,325	4,379	2,702	829	218	197
	Check	6,906	3,992	1,996	504	226	188
'65-I	Dem.	9,329	4,579	2,920	1,171	208	451
	Check	7,890	4,272	2,503	670	234	211
'65-II	Dem.	9,723	5,248	2,939	838	238	461
	Check	8,000	4,595	2,354	595	246	210
'66-I	Dem.	9,988	5,327	2,997	928	244	492
	Check	8,548	4,695	2,511	672	248	422
'66-II	Dem.	9,183	5,039	2,847	851	250	196
	Check	8,051	4,637	2,451	593	256	114
'67-I	Dem.	10,125	5,374	3,089	905	250	407
	Check	9,213	5,144	2,710	682	270	407
Average	Dem.	9,467	4,909	2,967	923	235	433
	Check	8,071	4,440	2,475	592	250	314
(in %)	Dem.	100.0	51.9	31.3	9.7	2.5	4.6
	Check	100.0	55.0	30.7	7.3	3.1	3.9
Extension:							
'67-II	Dem.	9,541	5,041	2,589	1,320	240	351
	Check	8,825	4,825	2,395	1,129	344	232
'68-I	Dem.	10,910	5,628	2,672	1,241	264	1,105
	Check	10,193	5,420	2,377	1,180	269	947
'68-II	Dem.	11,008	6,138	3,113	1,130	277	350
	Check	10,415	5,974	2,865	1,054	289	233
'69-I	Dem.	12,475	7,257	3,353	1,072	270	523
	Check	11,024	6,897	2,800	890	250	187
'69-II	Dem.	11,335	6,799	2,926	838	254	518
	Check	10,505	6,460	2,839	778	258	170
'70-I	Dem.	11,850	7,427	3,028	788	278	327
	Check	11,268	7,156	2,850	665	287	310
Average	Dem.	11,187	6,382	2,947	1,065	264	529
	Check	10,372	6,121	2,688	949	266	348
(in %)	Dem.	100.0	57.1	26.3	9.5	2.4	4.7
	Check	100.0	59.0	25.9	9.1	2.6	3.4

HIGHLIGHTS OF MY TRIP TO THE UNITED STATES

Chien-Pan Cheng

My trip to the United States in the fall of 1970 proved to be highly instructive and beneficial to my work in JCRR. I was invited to attend the Second International Symposium on Tropical Root/Tuber Crops held in Honolulu, August 23-30. This Symposium was co-sponsored by the College of Tropical Agriculture and the East-West Center of the University of Hawaii and attended by more than 60 participants from 22 countries. Mr. Li Liang, Specialist of the Chiayi Agricultural Experiment Station, was also invited to this Symposium. We presented two papers on sweet potatoes. Since most participants came from the islands of Hawaii, the West Indies, Oceania and Africa, the crop taro, a staple food in these areas, was given much emphasis in this Symposium. However, our achievement in sweet potato varietal improvement was acknowledged as the most fruitful piece of work among the participating countries/areas. The American delegates presented a general picture of the performance of sweet potato harvesting machines recently developed in the U.S. This information will prove useful to us in the near future.

After the Symposium was over, I went to the U.S. mainland to collect information and to familiarize myself with the new concepts and methods in both research and the applied aspects of large-scale production of corn, soybean, and peanuts. I spent about two weeks in Indiana, Virginia, and North Carolina, where I visited a number of agricultural colleges and experiment stations of the state universities. The following are the highlights of my travel in the U.S.

A. The outbreak of southern corn leaf blight:

This disease is not new, but in 1970 the mutant race of its pathogen, *Helminthosporium maydis*, race-T, had reached epidemic proportions. It attacked corn leaves, leaf-sheath, silk and also the ears. I was there right in time to see the severity of this disease, to watch how busily occupied the plant pathologists, corn breeders and government officials were, and how sad the corn farmers affected. Corn hybrids with Texas male sterile line as the female parent were highly susceptible to this new pathogen, and about 80% of the total corn acreage in the U.S. was related to the Texas male sterile line. An average yield loss of 20-30% was estimated by an unofficial but reliable source.

Corn is the number one field crop produced in the U.S. Its yield is about 4.5 billion bushels per year, as compared with wheat, 1.5; and soybean, 1.1. Besides yield loss and the hiking of corn price ($ 1.40 per bushel in spring, a 30-40% increase has been reported since the severe outbreak of this disease in the U.S.), the impact of this epidemic will be long lasting and wide-spread. The prices of other feed crops, such as soybean and sorghum, meat and poultry and all the food and industrial products made from corn either have already gone up or will soon go up, too. The disease outbreak affects not only the U.S. but also the other corn-importing countries of the whole world.

To find new resistant sources for hybrid corn is the only effective measure of controlling this disease. No chemicals could be used economically to control a disease on such widely planted acreage as in the case of corn and wheat. This is a very good opportunity to impress on the public the importance of crop disease-resistant breeding program in a nation's economy.

This disease has also created another serious problem to the corn industry - a short supply of next year's hybrid seeds. Three alternatives are being considered: 1) to establish seed nurseries either in Hawaii or in Central/South America in the latter part of 1970, 2) to grow hybrid sorghum instead of hybrid corn, and 3) to use F_1 seed at the risk of a theoretical loss of 20-30% in yield.

B. Farm machinery for peanut production

During my visits to the experiment stations and private farms in the U.S., much attention was given to the kinds of farm implements/machinery now being used as well as their research on machine-development programs. The most fruitful finding on this trip is that the peanut digger and harvester recently developed are needed badly in Taiwan.

Our peanut planting acreage is concentrated along the coastal regions of Yunlin, Chiayi and Tainan, with the record high acreage of 100,000 ha set in 1964. However, this was reduced to 90,000 ha in 1969, the main reasons for this reduction being labor shortage and increase in labor cost. Moreover, the cost of labor usually takes up about 60-70% of the total peanut production, because a great deal of manual labor is required for planting, digging and harvesting, as no suitable machines have been developed so far.

The machichs which I saw in Virginia and North Carolina performed very well in the field, and the same types of machine have been ordered for trial use in the peanut fields of Taiwan, I am sure that they can fit into our peanut cultivation system with only minor changes or by making slight modifications in our cultural practices to accommodate these machines.

C. The changing basic concepts of plant breeding

It was a real surprise to me to discover that in the short span of several years many basic ideas and principles of plant breeding have been so drastically changed. Taking corn breeding as an example, several years ago corn breeders believed that the highest yield always came from the double crosses. Today one can find many single crossed hybrids with agronomic characters superior to the double crosses and this trend is still growing. We were taught that continuous "selfing" of a cross-pollinated crop will gradually lose its vigor. However, it has been proved that this is not universally true. Some corn breeders have already succeeded in developing inbred lines of commercial value.

The traditional pedigree and bulk methods of plant breeding are also changing now. Many breeders are using the modified principles or the so-called new method in order to save both time and space and still enhance efficiency. The soybean breeder whom I met at Purdue University told me that it takes only 7-8 years now to develop a new soybean variety instead of 13-14 years in the past.

All the achievements mentioned above are, of course, attributed to thorough basic studies on genetics and other related sciences.

From what I saw in the U.S. where rapid progress was made in the farm machinery program, I deeply feel that to hasten the development of our own farm mechanization program, the recruitment of a team of well-trained, highly experienced personnel is a move of great importance. Since our farm size, natural environment, kinds of crop and cropping systems are different from those of the other countries, it is necessary to develop our own machine models for efficient adaptation to our farming practice in fulfillment of our own requirements. Meanwhile, we must realize that tractors and small tillers are only the power source for manipulating useful farm implements. To solve the problem of farm labor shortage, more attention should be paid to the development of various types of power-operated implements.

In conclusion, I wish to say that an information collection trip like the one I just took will be definitely beneficial to our program. It is my sincere hope that a new system could be set up by the Joint Commission to send a certain number of technical staff on short-term observation or study trips abroad to bring their knowledge up-to-date. This could be the most worthwhile investment in maintaining and stimulating the long-established JCRR spirit and enhansing our reputation.

RELATIONSHIP BETWEEN PRODUCTION COST OF MAJOR DRYLAND FOOD CROPS AND THE PRICE OF PORK IN 1960-69

Chih-Kang Chao

Evidently, this is not a likely topic for investigation by a crop production technologist whose limited knowledge of agricultural economics may lead to an unwarranted conclusion. However, the intent of the author to make this study is prompted by the following two motives: (1) to understand the recent changes in the production cost of major dryland food crops which exert a greater influence on the development of these crops than technical improvements; (2) to find out whether the pork price hike was due to the increased prices of feed crops.

The four major dryland food crops of sweet potato, peanut, soybean and corn are the important raw materials of feed and edible oil in Taiwan. Due to the adoption of improved varieties and farming practices as well as the increasing demand for these products for local consumption, the planted acreage of these crops have been rapidly expanded since the beginning of the first Four-Year Plan, with the exception of sweet potatoes the harvested area of which was reduced somewhat according to government policy in order to allot more land for growing other high-value crops. Peak acreage of these crops was reached during the third and fourth years in the Four-Year Plan, and was then gradually reduced to the present. This decrease was brought about mainly by two factors: (1) rising production cost to grow these crops and (2) large-scale import of low-priced soybean and corn. Since the easing of soybean and corn import controls in 1966, the farmers' enthusiasm in growing not only these two crops but also the other food and feed crops has been considerably dampened, especially peanuts and rapeseeds which have been replaced by imported soybean as sources of edible oil.

According to the data compiled in Table 1, the production cost of the crops listed have gone up to a large extent—sweet potato up by more than 4 times within 15 years, peanut 3.8 times within 14 years, soybean 85% within 12 years, and corn 31% within 3 years; yet the rise of their yield values lagged far behind. As shown in Table 1, the increase in value was only 78% for sweet potato, 2.5 times for peanut, 21% for soybean and 6% for corn. The dwindling of net returns on investments in these crops naturally discouraged the farmers from continuing to grow them.

Table 1. Production Cost of Four Major Dryland Food Crops

Unit: NT$/ha

Crop season	Yield (kg/ha)	Yield value	Production cost			Net returns	Labor & animal cost	Production cost per 100 kg
			Total	Direct	Indirect			
Sweet potatoes:								
Fall crop, 1955-56	19,816	6,942 (100)	4,376 (100)	3,196 (100)	1,180	2,566	1,457 (100)	19.3 (100)
Fall crop, 1957-58	21,141	7,655 (110)	5,276 (121)	3,896 (122)	1,380	2,379	1,997 (137)	22.3 (116)
Fall crop, 1958-59 & Spring crop, 1959	18,907	7,006 (101)	4,958 (113)	3,309 (104)	1,049	2,048	2,018 (139)	23.4 (121)
Fall crop, 1962-63	14,719	11,399 (164)	7,849 (179)	—	—	3,550	—	—
Winter crop, 1962-63	10,290	8,995 (130)	8,632 (197)	—	—	363	—	—
Fall crop, 1964-65	20,115	15,160 (218)	8,927 (204)	6,688 (209)	2,239	6,233	3,747 (257)	37.9 (196)
Spring crop, 1967	19,020	13,465 (194)	10,318 (236)	7,657 (240)	2,661	3,147	4,558 (313)	48.1 (249)
Fall crop, 1967-68	19,207	15,101 (218)	11,522 (263)	8,740 (273)	2,782	3,579	4,425 (304)	52.5 (272)
Winter crop, 1967-68	9,615	8,736 (126)	9,318 (213)	6,872 (215)	2,446	−582	3,601 (247)	83.0 (430)
Spring crop, 1968	16,912	14,221 (205)	13,804 (315)	10,682 (334)	3,122	417	5,081 (349)	70.3 (364)
Spring crop, 1969	21,060	13,962 (201)	12,379 (283)	9,697 (303)	2,682	1,583	5,106 (350)	59.9 (264)
Fall crop, 1969-70	20,165	16,055 (231)	18,535 (424)	13,953 (437)	4,582	−2,480	7,668 (526)	78.4 (466)
Winter crop, 1969-70	18,117	13,638 (196)	18,101 (414)	13,603 (426)	4,498	−4,463	8,140 (559)	85.2 (441)

Crop season	Yield (kg/ha)	Yield value	Production cost			Net returns	Labor & animal cost	Production cost per 100 kg
			Total	Direct	Indirect			
Peanuts:								
Spring crop, 1956	1,353	5,589 (100)	3,680 (100)	2,796 (100)	884	1,909	1,264 (100)	250 (100)
Spring crop, 1958	1,418	6,554 (117)	4,161 (113)	3,166 (113)	995	2,384	1,622 (128)	273 (109)
Fall crop, 1958	1,393	8,482 (152)	4,848 (132)	3,602 (129)	1,246	3,634	1,726 (137)	329 (132)
Spring crop, 1959	1,553	8,123 (146)	4,918 (134)	3,711 (133)	1,207	3,205	1,751 (139)	299 (120)
Spring crop, 1963	1,544	9,504 (170)	8,211 (223)	—	—	1,293	—	—
Spring crop, 1965	1,800	11,143 (199)	8,430 (229)	6,267 (224)	2,163	2,713	3,616 (286)	455 (182)
Spring crop, 1967	2,103	14,876 (266)	11,223 (305)	7,858 (281)	3,365	3,653	4,139 (328)	514 (206)
Fall crop, 1967	1,805	12,903 (231)	10,858 (295)	7,672 (274)	3,186	2,045	4,058 (321)	629 (252)
Spring crop, 1968	1,368	9,957 (178)	11,974 (325)	8,632 (309)	3,342	−2,017	4,587 (363)	864 (346)
Fall crop, 1968	2,123	18,029 (323)	13,891 (372)	10,171 (171)	3,720	4,138	5,493 (435)	629 (252)
Spring crop, 1969	1,880	12,782 (229)	11,276 (306)	8,205 (294)	3,071	1,506	4,990 (395)	578 (231)
Fall crop, 1969	1,944	15,767 (282)	14,022 (381)	10,289 (368)	3,733	1,745	5,437 (430)	698 (279)
Spring crop, 1970	1,805	14,179 (254)	14,183 (385)	10,816 (387)	3,367	−4	6,545 (518)	760 (304)

Crop season	Yield (kg/ha)	Yield value	Production cost			Net returns	Labor & animal cost	Production cost per 100 kg
			Total	Direct	Indirect			
Soybean:								
Summer crop, 1958	1,330	8,581 (100)	5,606 (100)	3,573 (100)	2,033	2,975	2,545 (100)	409 (100)
Summer crop, 1959 & Fall crop, 1959-60	1,171	9,212 (107)	5,180 (92)	3,688 (103)	1,492	4,032	1,804 (71)	421 (103)
Fall crop, 1962-63	1,448	10,351 (121)	5,390 (96)	—	—	4,961	—	—
Fall crop, 1967-68	1,784	9,591 (112)	9,160 (163)	6,040 (169)	3,120	431	2,542 (100)	491 (120)
Fall crop, 1968-69	1,547	7,903 (92)	9,358 (167)	6,415 (180)	2,943	−1,455	3,074 (121)	583 (143)
Spring crop, 1969	1,608	9,433 (110)	9,430 (168)	6,066 (170)	3,364	3	3,579 (141)	565 (138)
Summer crop, 1969	1,505	9,646 (112)	9,119 (163)	6,595 (189)	2,524	527	4,135 (163)	590 (144)
Fall crop, 1969-70	2,173	10,375 (121)	10,741 (185)	7,148 (200)	3,593	−366	3,726 (146)	550 (135)
Corn (hybrid):								
Winter crop, 1967-68	4,327	14,465 (100)	11,422 (100)	8,309 (100)	3,113	3,043	4,621 (100)	251 (100)
Winter crop, 1968-69	4,318	14,070 (97)	12,389 (109)	9,538 (115)	2,851	1,681	4,531 (98)	274 (109)
Spring crop, 1969	4,524	14,592 (101)	13,306 (117)	9,875 (119)	3,431	1,286	5,107 (111)	281 (112)
Fall crop, 1969	4,482	15,364 (106)	13,194 (116)	9,145 (110)	4,049	2,170	4,667 (101)	282 (112)
Winter crop, 1969-70	4,820	15,378 (106)	14,943 (131)	12,085 (145)	2,858	435	5,898 (128)	300 (120)

Source of data: Report on Agri. Basic Survey in Taiwan, 1957, 1959, 1960, 1966, 1968, 1969 and 1970 editions published by PDAF.

Of all crop production costs, the expenditures for labor and fertilizers usually account for the lion's share as indicated in Table 2. In 1969-70, the cost of labor was 41-45% for sweet potatoes, 39-46% for peanuts, 35-45% for soybean and 35-40% for corn. And the cost of fertilizers constituted 22-24% for sweet potatoes, 15-19% for peanuts, 13-16% for soybean and 27-35% for corn. Although the Government has urged the fertilizer manufacturers and the agencies dealing with fertilizer distribution to further lower the price of fertilizers, any significant reduction of crop production costs will depend largely upon efforts to cut down labor cost through: (1) mechanization of farming practices and (2) expansion of the size of individual farms. The latter is of particular importance, because the present average farm size is only about one hectare with the majority less than 0.5 ha. With farms of such small size, production cost cannot be cut down even by the use of highly efficient farm machineries.

Table 2. Percentage of Different Items Included in Production Cost of Four Major Dryland Food Crops, 1969 & 1970

Unit: NT$/ha

Crop	Total production cost	Direct production cost						Indirect** production cost
		Total	Seeds	Labor*	Fertilizers	Pesticides	Others	
Sweet potatoes:								
Spring crop, 1969	12,379	9,697	875	5,106	2,969	165	582	2,682
%	100	78	(7	41	24	1.3	4.7)	22
Fall crop, 1969	18,535	13,953	1,203	7,668	4,208	250	624	4,582
%	100	75	(6.5	41	23	1.3	3.2)	25
Winter crop, 1969	18,101	13,603	1,174	8,140	4,007	281	—	4,498
%	100	75	(6.4	45	22	1.6	0)	25
Peanuts:								
Fall crop, 1969	14,022	10,289	1,972	5,437	2,595	247	38	3,733
%	100	74	(14	39	18.8	1.8	0.4)	27
Spring crop, 1970	14,183	10,816	1,704	6,545	2,169	333	65	3,367
%	100	76	(12	46	15	2.3	0.7)	24
Soybean:								
Spring crop, 1969	9,430	6,066	849	3,579	1,239	399	—	3,364
%	100	64	(9	38	13	4	0)	36
Summer crop, 1969	9,119	6,595	613	4,135	1,342	403	100	2,524
%	100	72	(7	45	15	4	1)	28
Winter crop, 1969	10,741	7,148	774	3,726	1,684	592	372	3,593
%	100	67	(7	35	16	5.5	3.5)	33

Crop	Total production cost	Direct production cost						Indirect** production cost
		Total	Seeds	Labor*	Fertilizers	Pesticides	Others	
Corn:								
Spring crop, 1969	13,306	9,875	450	5,107	3,815	503	—	3,431
%	100	74	(3	38	29	4	0)	26
Fall crop, 1969	13,194	9,145	469	4,667	3,612	387	—	4,049
%	100	69	(4	35	27	3	0)	31
Winter crop, 1969	14,943	12,085	496	5,898	5,295	394	—	2,858
%	100	81	(3.4	40	35	2.6	0)	19

* Including cost for animal labor and minimal machine operation.
** Including depreciation, taxes, repair, interest on capital and land investment, etc.
Source of data: Report on Agri. Basic Survey in Taiwan 1969 and 1970, PDAF.

In spite of the fact that the cost of production showed an upward trend during the past ten years, the price of most feed materials not only remained low but also some feed items, especially corn and soybean cake/meal, two of the main components of concentrated hog feed, had their prices reduced by 23% and 27% respectively in 1969 as compared with those in 1960, as shown in Table 3. On the other hand, the price of hog increased by 16% and that of pork in Taipei City by 32% within a period of 10 years.

Table 3. Price Fluctuations of Feed Materials and Pork During 1960-69

Product	Wholesale price in production areas (NT$/kg)										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Index*
Sweet potato	0.87	0.79	0.81	0.96	0.69	0.89	0.82	0.91	0.90	0.80	92
Soybean	7.12	6.17	7.02	7.06	7.01	6.52	7.14	6.23	6.04	5.78	81
Corn	4.20	4.18	4.26	3.05	3.34	4.11	4.01	3.60	3.17	3.22	77
Sweet potato chips	2.42	2.22	2.29	2.75	2.13	2.53	2.37	2.67	2.96	2.31	95
Cassava chips	—	—	—	2.91	2.65	2.35	2.38	2.90	3.10	2.66	91
Wheat bran	3.99	4.21	4.00	4.04	3.47	3.80	3.68	3.66	3.66	3.54	89
Soybean cake	7.32	6.59	6.75	7.09	6.17	6.30	7.28	5.91	5.49	5.31	73
Peanut cake	6.35	5.66	5.25	6.31	5.57	5.82	6.41	6.69	5.90	5.90	93
Hog	17.29	17.29	15.84	17.97	19.40	19.57	19.45	19.31	21.66	20.04	116
Pork** (Taipei City)	35.37	34.37	33.77	36.57	37.90	40.75	40.75	43.33	45.97	46.82	132
Pork (Provincial Av.)	—	—	—	—	37.12	37.00	38.22	39.27	41.67	43.24	116

* Index of prices in 1969 compared with those in 1960 (or cassava chips in 1963, Prov. av. pork price in 1964).
** Shoulder Butt.
Source of data: Taiwan Agricultural Prices Monthly, March 1970.

Because feed consumption constitutes around 70% of he total hog-raising cost, people often attributed the high price of pork to the increase of feedstuff prices. As a matter of fact, this is not true, at least during the past 10 years as shown in Table 3.

With the decline in feed prices and the steady increase in the price of pork and pork consumption (from 175,100 m.t. in 1960 to 346,510 m.t. in 1969, according to records kept by PFB), hog raising seems to be a very profitable subsidiary occupation of the farmers in Taiwan. In fact, the net returns from raising hogs for an average 8-month period averaged only NT$ 100-300 per hog, and even less in some years, according to a survey made by PDAF. However, the net profit per hog shared by pork wholesalers went up to NT$ 700, according to PFB. It is quite evident that unless the problem of marketing is solved, the price of pork can not be reduced no matter how low the feed prices are.

QUALITY CONTROL OF VEGETABLE SEEDS IN TAIWAN

Cheng-I Lin

In the past decade, much work was done to control the quality of seeds of major field crops in Taiwan. By strictly following seed certification practices, certified seeds of superior quality are now available for general distribution.

As for other crops, particularly vegetables, relatively few seed quality control measures are imposed at present. As a result, no guarantee for the quality of seeds purchased by farmers from the local seed market can be expected, so there are frequent complaints about poor seed quality by foreign seed buyers.

To protect farmers from purchasing low quality vegetable seed and to expand the vegetable seed market abroad, the following measures are recommended for implementation during this calendar year.

1. Labelling seeds for sale

This is essentially the same as the seed law enforcement prevailing in many other countries. Seeds ready for sale should be accompanied by a label containing the following information: (1) kind of seed, (2) name of variety, (3) provenance, (4) net weight, (5) purity, (6) germination percentage, (7) date of germination test, (8) name of seed company and its address, etc. In principle, only seed with proper labelling can be sold. The judgment of seed quality is left to the farmers themselves by reading the attached label.

The Seed Technology Section of PDAF is responsible for making inspections of seed stores at irregular intervals to check whether the seeds are properly and honestly labelled and, if necessary, to procure seed samples for further testing. Any violation found is subject to penalty as prescribed in the Legislation Governing Seed Industry in Taiwn.

2. National seed standards and labelling for promotion of foreign trade

According to the Seed Legislation Governing Import and Export of Seeds, seeds should be thoroughly tested by the Bureau of Commodity Inspection and Quarantine, and only those seeds which have met the requirements as stated in the National Seed Standards are allowed to be imported or exported.

In the National Seed Standards, however, only the minimum standards of the following items are maintained, such as: (1) seed moisture content, (2) percentage of pure seed, (3) percentage of other crop seeds, (4) percentage of weed seeds, (5) percentage of inert matter, and (6) percentage of germination.

Since the above information is far from sufficient to denote the quality of seeds, particularly their genetic quality, the National Seed Standards should be revised to include more comprehensive information required for better seed marketing. Toward this end, the Bureau of Commodity Inspection and Quarantine has to make tests to see if the seeds are properly and truly labelled and whether they meet the minimum seed standards. Only those seeds having satisfactorily passed all the tests are approved for export and import. In case of necessity, the said Bureau can make either post-export or post-import control tests for the evaluation of genetic quality. This was put into practice four years ago.

3. Field inspection of vegetable seeds for export

True-to-variety and varietal purity are the two most important criteria in determining seed quality in question. In fact, many complaints of foreign buyers stemmed from this origin.

Any laboratory seed testing usually finds it difficult to identify the varieties in mixture even with the supplementary seedling test. The most reliable way to attain this goal is to conduct strict field inspections.

At present, only four kinds of vegetable seeds—radish, Chinese kale, edible rape and cauliflower—are subject to compulsory seed certification, including both field inspection and laboratory seed testing, before being exported. This practice will be extended gradually to other kinds of vegetable seeds this year and it is expected that the same practice will be extended to other crop seeds within three years.

There is no doubt that many measures other than legislation mentioned above can also help improve the quality of vegetable seeds. In this connection, mention should be made of the following two standards.

4. Varietal purification in TSS and other agricultural stations

Under the support of JCRR, purification work on vegetable varieties is proceeding satisfactorily in the Taiwan Seed Service and other agricultural stations. After three years of hard work, TSS is now ready to hold a field day to demonstrate its purified varieties of several kinds of vegetables. The seeds thus produced will soon be sold to seed merchants as stock seeds for production of extension seeds for export.

5. Private plant breeding stations

Recently two more private breeding stations have been added to the one established about ten years ago. All the stations have adequate facilities and competent technical staff to conduct plant breeding work. Since they all have business connections with the foreign markets, maintenance of variety purity and production of stock seeds of high varietal purity are essential besides breeding their own varieties. The establishment of private breeding stations, therefore, is instrumental in boosting our seed industry.

In conclusion, the improvement of the quality of vegetable seeds constitutes the mutual goal of both public organizations and private concerns through whose joint effort rapid strides in further development of our seed industry can be expected. In this sense, the establishment of a China Seed Improvement Association to have all interested parties represented may be regarded as a big step toward this goal.

IMPROVING MEASURES AND FACTORS ESSENTIAL FOR SEED INDUSTRY PROMOTION IN TAIWAN

Chia-Chi Chen

A. Improvement of rice seed multiplication

The three-level rice seed multiplication, viz., foundation seed, stock seed and extension seed, has been practiced in Taiwan since the release of the first improved variety, Nakamura, in 1926. It was only in 1957 that a modernized system of rice seed multiplication and certification was put into practice.

The 5,000 metric tons of seed needed by local farmers every year were formerly produced by 1,700-odd farms scattered widely over practically all the townships on this island. Because of this, the past efforts made to improve seed quality, such as better farming practices, roguing of off-type plants, cooperative pest control and strict field inspection achieved only limited success.

As a remedial measure, a new approach through cooperative seed production was adopted through the joint effort of JCRR, PFB and PDAF in the second crop season of 1970. Instead of producing extension seed in all the townships, each hsien was divided into three sections according to their respective geographic location and crop-planting acreage, and only one township of each section was selected to supply the seeds needed by those townships lying within the section.

To increase work efficiency of field inspectors, who were permanently stationed in Taichung, arrangements were made for them to be located at the five DAISs in west Taiwan, so that each field inspector can easily make thorough field inspections within his area, to ensure better performance on the over-all seed multiplication program, besides assisting the local government officials in planning, implementing and supervising the seed multiplication program as well as collecting and distributing certified extension seeds.

With a view to lightening the heavy workload of PDAF inspectors, 35 licensed field inspectors of non-government agencies were engaged to render help to the respective PDAF field inspectors. Since the implementation of this improved program, much progress has been made in the following fields.

The 1,235 rice extension seed farms were merged into 136 farms in an equal number of villages at 51 townships instead of 1,137 seed farms scattered widely over 1,058 villages at 262 townships in the second crop season. The average yield per hectare in the cooperative seed farms has been raised by 4-30% as compared with that of the conventional rice field.

For the first time in Taiwan, field inspection of all the rice extension seed farms has been made possible with a limited number of official seed inspectors; and fully representative seed samples can now be collected by the official seed certification agency to ensure correct evaluation of the quality of seed distributed for planting. Official sealing of the certified seed bags with metal seals is now practised for the first time to guard against adulteration. During the same period much improvement was shown in the varietal purity of the extension seeds produced. The high percentage of 60-70% admixture formerly found in seed samples showed a 30 percent decrease due to strict seed certification achieved in this program.

B. Factors essential for the promotion of seed industry

1) Seed processing:

Seed processing is designed to upgrade seed quality and improve seed planting value by removing admixtures such as weed seed, trash and broken seed; and to condition the seed for better storage until planting time. Thus the objectives of seed processing are to remove undesirable elements from field-run seed, alter seed condition to render them plantable, apply protective chemicals, and package seed in easily-handled, sturdy containers. During the course of processing, seeds are moved through machines to remove undesirable parts to improve seed purity, germination, or plantability. Moreover, it improves seed appearance—the first factor considered by seed merchants. To modernize the seed industry, the first thing to do is, of course, to strengthen equipment and facilities in the seed processing laboratories.

2) Seed vigor:

Seed quality is determined primarily by germination and purity tests. The former indicates the percentage of seed that will produce normal seedlings under favorable growing conditions, while the latter shows the percentage of weed seed, other crop seed and inert material mixed with the crop seed. However, to improve the germination of seed alone is not sufficient. Nowadays both farmers and seedsmen in other countries are paying much attention to potential seed performance, i.e., seed vigor.

The study of the effect of seed vigor on plant performance has been limited to food crops, with little regard for vegetables. Therefore investigation of the effect of seed deterioration on crop production is an important undertaking in seed technology. Also, introducing the concept of seed vigor into the minds of farmers, seedsmen, and seed merchants in Taiwan is one of the effective means for the promotion of the seed industry.

3) Seed coating:

Recently, mechanization of the

entire process of crop production has gained momentum and more and more farm machinery and implements are being developed or introduced from abroad for trial use to determine whether or not they are adaptable for local use. The adoption of seed-coating method for use in a seeding machine is one of the ingenious ways to attain uniformity of seeds planted, as seeds vary in size, length, and weight, especially vegetable and flower seeds. To make the seeds uniform in size by coating will greatly facilitate mechanical sowing of seeds.

EXPERIMENTS ON BANANA STORAGE

Fu-Wen Liu

In commercial practice, bananas are harvested green and shipped in green, hard condition. When bananas start to ripen before arriving at their destination—usually in a ripening house, they are regarded as waste or loss. Therefore, various storage techniques, in addition to refrigeration, have been tried to protect green bananas from premature ripening during the shipping period. The use of polyethylene bags and ethylene absorbents and the application of controlled atmosphere (CA) storage techniques are some of the new approaches. Recently, several experiments on banana storage have been carried out by the author and his research assistants at the Taipei District Agricultural Improvement Station (Taipei DAIS). Reported hereunder are the preliminary results of the experiments:

Storage of green bananas in polyethylene bags

Green bananas in clusters which had been washed and dipped in 800 ppm of TBZ (Thiabendazole) suspension and then air dried were stored at 71°F or 57°F under the following treatments:

1. In perforated polyethylene bag.

2. In sealed polyethylene bag.

3. In sealed polyethylene bag with the air in the bag pumped out and replaced with nitrogen.

4. In sealed polyethylene bag (0.04 mm thick) but containing ethylene absorbent (potassium permanganate absorbed in vermiculite blocks).

Each bag contained four clusters of bananas weighing 3.5-5.0 kg. The gases (CO_2 and O_2) in each sealed polyethylene bag were analyzed with an Ozat apparatus twice a week (Mondays and Thursdays) throughout the storage period. At the end of storage, the bags were unsealed and the bananas ripened with acetylene gas produced by adding water to calcium carbide. The eating quality and shelf-life of the ripe bananas were also studied.

In previous experiments it was found that the perforated polyethylene bags could not prevent green bananas from ripening, but were able to protect them against desiccation or too rapid transpiration when compared with bananas similarly stored in the open air. Therefore this treatment can be used as a check for the other treatments.

The effect of TBZ treatment on the control of cushion rot has also been studied by comparing TBZ treated and untreated banana clusters sealed in polyethylene bags and stored at 71°F.

While these experiments are still underway pending more conclusive results in the near future, preliminary findings found to date are summarized as follows:

1. The concentration of CO_2 in each polyethylene bag reached its constant of about 5-7% a few days after being sealed with green bananas inside. The O_2 concentration at the same period, however, fluctuated widely usually from 2% to 7%. After a certain period of storage, a sudden rise of CO_2 well above 10% accompanied by a drop of O_2 concentration to a level below 1% in the bag was noticed.

2. When the polyethylene bags were unsealed before or immediately after the beginning of the sudden rise of CO_2 concentrations in them, the bananas stored inside remained green and hard, and they could be ripened normally afterwards. On the other hand, if the bags were unsealed a few days after the significant rise of CO_2 concentrations in them, the bananas inside the bags would be more or less softened and they might not ripen normally afterwards. It is, therefore, postulated that the beginning of the sudden rise of CO_2 concentration in the bag coincides with the start of the respiratory climacteric rise of the bananas sealed within. The interval between the commencement of the experiment and the sudden rise of CO_2 concentration is, thus, considered the safe period for the storage of green bananas.

3. Taking 100-200 ml of air samples for analysis twice a week from each bag sealed with bananas inside seemed to have no effect on the atmospheric components in the bag when compared to similar bags which had not had air samples taken so often.

4. Thiabendazole was found to be a very effective fungicide to control cushion rot of banana clusters sealed in polyethylene bags, provided that the clusters were so trimmed that the stem tissue (bunch stalk tissue) was completely removed.

5. In most of the cases, sealed polyethylene bags were helpful in delaying the ripening process of green bananas. However, the duration of delayed ripening of bananas in the sealed polyethylene bag varied a great deal with different banana samples used in experimentation, ranging from several days to several weeks. Pumping out air from the bags and then filling them with nitrogen seemed to have little or no effect on delayed ripening of stored green bananas. This practice could immediately lower the O_2 concentrations in the bags to the level of 4-6%, but at the end of three days there would be very little difference in the O_2 concentrations whether or not the bags were filled with nitrogen.

6. The method of storing green bananas in sealed polyethylene bags with ethylene absorbent produced promising results, as it succeeded

in delaying the ripening process of green bananas. This method is particularly beneficial to the stored bananas which are apt to ripen rapidly under the conventional method of storage. According to the results of the three experiments each with six replications, the newly harvested bananas could stay green and hard in sealed polyethylene bags with ethylene absorbent for at least five weeks at 71°F temperature. A longer period could have been possible at 57°F temperature.

Bananas stored under controlled atmosphere

Green bananas in clusters were stored in specially designed chambers made of galvanized iron plates. Approximately 30 kg of green bananas were sealed in each chamber with a capacity of around 90 liters. Ethylene absorbent (potassium permanganate in vermiculite blocks) was placed in some chambers but not in check chambers used for comparison. CO_2 was built up by the respiration of bananas in the chamber and maintained at a level of 6-8% by removing excess CO_2 with KOH aqueous solution in an absorption chamber, which has been so designed that the air flowing between the storing and the absorption chambers can be stopped totally by applying a clamp to each rubber tubing. The O_2 in the chamber was consumed by respiration of bananas and maintained at a level of 1-2% by introducing fresh air into the chamber through rubber tubings whenever its concentration became too low.

As this experiment is still going on, the experimental findings reached by now are that green bananas cannot be stored long in the chamber without an ethylene absorbent, for after a storage period of about three weeks, the CO_2 production rate in the chambers would register a sudden rise and the bananas inside become soft almost at the same time. Now banana clusters stored in most of the chambers with an ethylene absorbent remain green for more than one month under 71°F or 57°F temperature without showing any sign of ripening. Just how long they can be stored in this manner requires further observation.

PROMOTION OF INTEGRATED SUMMER VEGETABLE PRODUCTION

Ching-wu Shen

In sub-tropical and tropical Taiwan, fresh vegetables are always in short supply during the summer months when high temperature and high humidity (Tables 1 and 2) greatly restrict vegetable production. In order to maintain a steady supply of vegetables during the summer season, a project was initiated in 1969 with special emphasis on technical innovation, varietal and cultural improvements, pest and disease control and proper handling of vegetable products. Through the implementation of this project, the situation of summer vegetable shortage has heen much improved, especially in the Taipei area.

Table 1. Mean Temperature in Taiwan (°C)

Locality	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Taipei	15.3	15.0	17.1	20.7	24.2	26.6	28.2	28.0	26.5	23.1	20.0	16.9
Taichung	15.8	15.9	18.4	22.0	25.4	26.9	27.8	27.6	26.7	23.5	20.7	17.4
Tainan	17.1	17.3	20.0	23.4	26.4	27.4	27.9	27.6	27.3	25.0	21.8	18.6

Table 2. Mean Relative Humidity in Taiwan (%)

Locality	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Taipei	84	84	84	82	82	81	78	78	79	81	81	83
Taichung	81	82	82	82	82	82	81	82	80	78	79	80
Tainan	79	79	79	80	81	84	83	85	82	79	79	80

In 1969, JCRR subsidized the sponsoring organizations with NT$ 4,500,000 to implement the project of promoting summer vegetable production in north Taiwan. In this project the area of vegetable farms at the outskirts of Taipei was increased by 485 ha to a total of 1,500 ha. Consequently, sufficient quantities of vegetables were produced for the metropolitan markets that summer. There were altogether 23 kinds of vegetables produced at a monthly output of some 6,000 metric tons.

Under the same project, short-term training in vegetable cultivation was given to 40 extension workers and some 4,000 growers, while technical supervision of the culture and plant protection work in the different areas was carried out by 30 technical workers from various research institutions and district agricultural improvement stations. The growers were organized into 167 teams to participate in cooperative pest control over 10 hectares of lowland and 5 hectares of slopeland. To help set up more vegetable gardens, JCRR shared the expense for the construction of new farm roads leading to the new production sites where small reservoirs had been built as more dependable sources of irrigation water. Also built were six vegetable-packing houses in the producing areas for the convenience of marketing vegetables.

In 1970, a total of 5,380 hectares of vegetable farms in central and northern Taiwan was devoted to growing vegetables in the summer. Twenty-five kinds of vegetables representing 50 varieties were planted, producing some 13,000 metric tons monthly, more than enough for local consumption.

Following the practice of 1969, short-term training was again provided for 42 extension workers and some 5,000 growers. To facilitate marketing of vegetables, JCRR again subsidized the construction of farm roads to the production sites and eight more packing houses in the main vegetable-producing areas. More small reservoirs were built to provide adequate irrigation water.

Table 3. Location and Acreage of Summer Vegetable Production Sites

Location	1969			1970		
	Acreage (ha)	No. of production teams	No. of growers	Acreage (ha)	No. of production teams	No. of growers
Shuangyuan	50	5	100	129	5	100
Neihu	10	2	77	27	2	77
Shihlin	200	22	400	543	26	540
Peitou	110	14	192	231	16	214
Hsinchuang	20	2	61	73	2	67
Luchow	250	25	400	487	30	452
Panchiao	240	21	618	1,309	25	734
Hsintien	10	1	34	28	2	34
Sanchih	50	9	104	69	11	120
Tanshui	40	3	34	139	4	63
Sanhsia	40	2	57	—	—	—
Ilan	20	2	35	—	—	—
Taoyuan	302	39	1,189	360	29	769
Hsinchu	158	20	612	683	10	294
Hsinshe	—	—	—	100	5	93
Yuanlin	—	—	—	289	15	644
Yungching	—	—	—	387	15	654
Chihu	—	—	—	526	17	439
Total:	1,500	167	3,913	5,380	214	5,294

To promote integrated vegetable production, the farmers in the vegetable-producing areas were organized into production teams by the local FA's according to the distribution of farm sites. The main functions of the teams are to exchange vegetable production and plant protection techniques among the team members; to make joint decisions on the suitable kinds and varieties of vegetables to be planted; to participate in coordinated work operations among production teams such as irrigation, raising seedlings, grading and packing; to decide on cooperative application of pesticides; and to assist in the application for and the distribution of vegetable production materials.

Seedling nurseries, 0.1-0.3 ha each, were established under the supervision of local FA's, with seeds, fertilizers, pesticides and building material (plastic sheets) subsidized by JCRR. Vegetable seedlings raised in the plastic sheet-covered nurseries during the summer were not affected by inclement weather, thus healthy seedlings could be supplied immediately for replanting in the wake of a damaging storm or typhoon. Meantime, JCRR subsidized the construction of vegetable-packing houses each of 25 pings in size to handle grade and pack vegetables to enhance their commercial value and also of reservoirs and wells to improve irrigation in the vegetable-producing areas. Attempts were made to extend the new heat-tolerant vegetable varieties introduced from the tropical countries and to adjust the time of vegetable production to meet seasonal demands by making decisions on planting time and locations at different altitudes.

Technical supervision over culture and plant protection work was carried out in the vegetable-producing areas by technicians from various agricultural research institutions. A training class in special techniques was conducted for the extension workers from the different areas to acquaint them with modern knowledge of summer vegetable production before proceeding with extension work.

The only unpredicable element in summer vegetable production is the threat of typhoons which usually occurs in the summer season. During a typhoon many hectares of vegetable farms would either be inundated or be covered with silt, thus requiring immediate emergency rehabilitation of the typhoon damaged farms for early resumption of production. Since 1969 JCRR has earmarked a substantial sum of emergency funds for relief to typhoon-afflicted vegetable growers. The two typhoons, Elsie and Flossie, which swept over Taiwan in the early fall of 1969 and Typhoon Fran in September 1970 wrought severe damage to large areas of vegetable farms near Taipei, as vegetable crops on more than a thousand hectares of vegetable farms at six townships were almost completely washed away. To render timely assistance to the vegetable growers for immediate replanting of their crops, JCRR provided them with nitrogenous fertilizer of urea at the rate of 150 kg per ha in 1969 and 100 kg per ha in 1970 for restoration of soil fertility washed away by flood water.

Table 4. Quantity of Urea Fertilizer Distributed

Locality	1969		1970	
	Devastated acreage (ha)	Quantity of urea (kg)	Devastated acreage (ha)	Quantity of urea (kg)
Luchow	210	31,500	250	25,000
Shihlin	160	24,000	235	23,500
Panchiao	200	30,000	158	15,800
Shuangyuan	50	7,500	40	4,000
Hsinchuang	20	3,000	13	1,300
Hsintien	—	—	4	400
Total	640	96,000	700	70,000

Table 5. Length of Farm Roads Constructed (1969)

Locality	Length of roads (m)	Acreage of vegetable farms benefited (ha)
Hutien Li (Yangmingshan)	1,687	98.6
Hushan Li (Yangmingshan)	470	26.6
Chuanyuan Li (Yangmingshan)	425	19.7
Total	2,582	144.9

Due to the timely implementation of the project on promotion of summer vegetable production in 1969, the supply of vegetables that summer was fairly constant (Table 6), and the price of vegetables (Table 7) stable the whole season, except in the month when the two typhoons hit Taiwan. As shown in the following table, the quantity of summer vegetables produced in 1969 and 1970 showed a marked increase as compared with that in previous years.

Table 6. Volume of Vegetables Transacted in Taipei Wholesale Markets (M.T.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1967	7,130	5,057	5,838	5,901	6,450	5,059	4,677	5,812	4,892	5,508	6,041	7,169
1968	9,724	6,212	6,748	5,749	6,299	4,989	4,249	4,509	4,769	6,124	6,911	8,427
1969	11,354	8,777	10,331	8,483	7,628	6,544	7,370	8,666	6,763	4,980	7,521	10,812
1970	10,613	9,822	11,320	11,299	10,623	9,578	8,962	8,117	6,768	7,785	8,060	9,108

Table 7. Average Wholesale Price of Vegetables in Taipei (NT$)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1967	1.60	1.55	1.33	1.50	1.37	1.79	1.74	1.70	1.87	1.94	1.97	1.80
1968	1.15	1.15	1.28	1.65	1.59	2.14	2.14	1.87	2.07	2.10	1.46	1.10
1969	1.32	1.40	1.58	1.69	1.83	2.24	2.23	1.80	2.35	4.25	2.84	1.70
1970	1.23	1.18	1.36	1.44	1.62	1.64	1.83	2.20	2.97	2.38	2.40	2.14

Owing to the vigorous promotion of integrated summer vegetable production, we have succeeded in producing sufficient quantities of vegetables in the summer season over the past years. Table 8 shows that prior to 1968 the supply of vegetables in the summer was low, occupying only 30-32% of the total production, whereas vegetables produced in the winter amounted to 68-70%, more than double what was produced in the summer.

Table 8. Comparison Between Summer and Winter Vegetable Production in 1961-70

Year	Total production[1]	Production in summer[2]		Production in winter	
	M.T.	M.T.	%	M.T.	%
1961	680,518	212,252	31	468,266	69
1962	694,842	216,386	31	478,456	69
1963	735,508	228,527	31	506,981	69
1964	803,378	253,484	32	549,894	68
1965	799,886	266,599	33	533,287	67
1966	753,943	242,661	32	511,282	68
1967	834,798	267,306	32	567,492	68
1968	967,045	292,524	30	674,521	70
1969	1,320,399	514,770	39	805,629	61
1970	1,489,844	666,280	45	823,564	55

[1] Excluding the production of mushroom, asparagus and bamboo shoot.
[2] Summer season is from May to October.

As a result of the implementation of the project to increase summer vegetable production in 1969, the volume of summer vegetables produced during that year registered a sharp increase, while in the following year a phenomenal rise in production was realized. For the first time, the vegetable produced between the winter and summer seasons was about equal, because there was only a 10% difference between the seasons. Thus, efforts made to increase the supply of summer vegetables has not only been rewarding but also met the need for adequate nutritional intake during the hot summer months in Taiwan.

PAPAYA PRODUCTION IN TAIWAN

Kuo-liang Chang

General description

Papaya (*Carica Papaya* L.), a popular fruit native to tropical America, is now widely grown in other tropical regions. It has even been naturalized in places where warm weather prevails, such as Taiwan and other provinces in South China.

The papaya plant is a shrub, almost an herb in succulence, the trunk tissue of which may survive for a considerable number of years. It begins to bear fruit one or two years after planting when the trunk is only 70 cm in height. Its annual yield varies from 30 to 70 kilograms per tree, depending on the variety planted. Occasionally, a plant may become unproductive when it grows too tall for a good yield.

Due to the complexity of sex expression of papaya plants and flowers and the influence of environmental factors, papaya trees are generally divided into three groups: male, female and hermaphrodite. The fruiting of male trees and the change in the nature of flowers as well as fruit of hermaphrodite trees appear to be influenced by temperature, accentuated by coolness or short photoperiod or both. Perhaps temperature plays a more significant role in determining plant growth as well as its fruiting habit, without ruling out other influences that sometimes make male trees bear fruit only when young or sometimes only when aged.

Although low temperature reduces growth and yield, the most pronounced effect of cool weather is on the flavor and ripening of fruit. When some exotic varieties were introduced for trial planting in southern Taiwan, it was observed that fruit set in late autumn required more than five months to become ripe, while in the spring or summer it took only three months.

Chilling not only affects the inner processes of papaya but also causes skin changes whereby its resistance to organisms causing rotting is reduced. As a matter of fact, some Solo varieties grown on this island bear fruit somewhat bitter in taste, sometimes with small spots appearing on the skin of the fruit in the winter season. In order to reduce chilling damage to produce a higher percentage of marketable fruit, a series of field experiments was carried out at the Fengshan Tropical Horticultural Experiment Station in 1970. Polyethylene bags wrapped over fruits during the cool season were found effective in preventing chilling damage.

The duration from seed sowing to harvest of the first fruit is different in different varieties and climates. Trees of the Solo variety planted in Florida, for example, sometimes do not flower until twelve to eighteen months later, whereas in southern Taiwan the same Solo trees may yield the first fruit in or about twelve months after planting. However, other varieties, such as Hybrid No. 1 (Philippine variety x Solo line 1) and Hybrid No. 2 (Philippine variety x Solo line 9), grown here do not bear fruit until after fourteen months or more.

Areas and production

In Taiwan, papaya was first introduced from the mainland about two to three hundred years ago. It was planted in home gardens and then in the open fields years later. The growing area was, at first, restricted to the southern part of this island, gradually spreading to central and northern Taiwan after the fruit had been generally accepted as palatable. The southern districts of Pingtung, Kaohsiung and Tainan are now the main production areas where the weather condition is more favorable than that in the north. The following two tables show the distribution and production of papaya in recent years.

Distribution and Production of Papaya in Taiwan in 1969

Prefecture	Planted area (ha)	No. of plants	Production (M.T.)
Taipei	5	4,231	45
Ilan	11	7,792	117
Hsinchu	37	34,085	203
Miaoli	12	10,132	132
Taichung	20	12,189	342
Changhua	56	58,139	459
Nantou	19	18,468	384
Chiayi	68	71,188	1,097
Tainan	174	159,308	3,197
Kaohsiung	256	304,964	5,069
Pingtung	255	302,207	5,417
Taitung	106	92,770	2,054
Hualien	45	54,642	642
Others	20	18,075	223
Total	1,084	1,148,190	19,381

Production of Papaya in Taiwan in 1960-69

Year	No. of yielding plants (plant)	Harvested area (ha)	Production (M.T)
1960	646,169	460	9,104
1961	690,404	540	10,584
1962	696,865	549	10,471
1963	690,853	559	10,527
1964	726,505	658	11,700
1965	811,420	686	12,669
1966	1,110,711	763	13,672
1967	1,037,522	790	16,648
1968	1,115,192	885	18,632
1969	1,148,190	907	19,381

Source: Taiwan Agricultural Yearbook, 1970

Papaya production compared with that of other major fruits

The rate of increase in papaya production on this island during the past ten years is rather slow when compared with that of banana or citrus, though faster than that of pineapple. This situation may be explained by the fact that papaya is mainly for domestic consumption, while the other three are regularly shipped to foreign markets in both fresh and processed forms. The following table shows the production situation of papaya in comparison with other fruits in the past decade:

Production of Papaya Compared with Other Fruits (1960-69)

Kind	Production (1,000 M.T.)		Index of development (ID)
	1960	1969	
Papaya	9	19	2.1
Banana	114	585	5.1
Pineapple	166	325	1.9
Citrus	52	170	3.2
Japanese apricot	2	24	12
Mango	4	12	3
Litchi	1	7	7

Source: Taiwan Agricultural Yearbook, 1970.

As Japan has been importing large quantities of papaya from Hawaii since 1969, the situation of papaya production on this island may be greatly changed if Taiwan can produce papaya for shipment to Japan at a lower price and better quality to compete with that from Hawaii, provided the problem of fruitfly (*Docus dorsalis*) and melonfly (*D. cucurbitae*) infestation can be solved to meet Japanese quarantine requirements.

Horticultural characteristics of introduced varieties

Besides the papaya varieties introduced from mainland China long ago, more than ten cultivars were recently introduced from other countries for varietal improvement, and they have been placed under observation at several agricultural experiment stations. The horticultural characteristics of the major cultivars as observed by the Fengshan Tropical Horticultural Experiment Station in 1970 are given in the following table, in which "Sunrise Solo" and "Kapoho Solo" are the two most promising varieties with desirable characteristics suitable for extension in the immediate future.

Horticultural Characteristics of Major Papaya Cultivars

	Solo Line 1	Solo Line 9	Hybrid No. 1	Hybrid No. 2	Sunrise Solo	Kapoho Solo	Costa Rica Red
Days between sowing and fruiting	234	229	256	255	215	250	226
Height of trees starting fruiting (cm)	81.5	80.7	76.67	71.60	76.0	114.0	72.28
Condition of fruit setting	Crowded	Moderate	Moderate	Moderate	Moderate	Distantly crowded	Moderate
Uniformity of fruit	Uniform	Hermaphrodite fruit disorder	Uniform	Uniform	Very uniform	Uniform	Uniform
Sterility of hermaphrodite trees	Frequent	Frequent	Frequent	Frequent	None	None	None
Hermaphrodite fruit shape:							
Elongata (%)	84.66	66.46	78.24	77.96	96.42	97.0	79.63
Pentandria (%)	3.62	17.41	10.80	10.91	0.89	0	14.81
Intermediate (%)	11.72	16.13	10.65	11.13	2.67	3.0	5.56
Average fruit weight (gm)	684.64	476.65	1,650.60	1,336.70	395.50	243.20	868.00
Flesh color	Deep orange yellow	Fresh red	Light yellow	Light yellow	Orange red	Orange yellow	Red
Sugar content (Brix °)	12.39	12	10	10.5	14.88	13.95	13.08
Flavor	Weak	Weak	None	None	Strong	Strong	Special
Table quality	Good	Good	Poor	Poor	Excellent	Good	Good
Keeping quality	Good	Poor	Poor	Poor	Medium	Excellent	Poor

Note: Data compiled by the Fengshan Tropical Horticultural Experiment Station.

SERICULTURE FARMING PROGRAM IN TAIWAN

Pa-Lun Chang

Present status of sericulture farming

Even up to the present, sericulture farming in Taiwan remains a side line occupation of farmers. Owing to the scattered raising of silkworms in mountain areas and the low yield of cocoons, the cost of cocoon production has been fairly high. Meanwhile, from the lack of standard facilities and equipment, raw silk produced by most of the silk reeling plants is not only of low quality but also at high production cost. As a result, the price of raw silk sold in the local market has been as high as NT$ 900 per kg which is about 30% higher than that in the international market. This naturally constitutes the most important factor that handicaps the silk industry from keeping abreast with the other booming industries.

To solve this problem, a new pattern in sericulture farming employing intensive techniques of mulberry planting and silkworm raising has been followed in some parts of the Island since 1969. To increase labor productivity, the application of labor-saving devices for silkworm feeding and methods for outdoor mulberry shoot-feeding of labor stage silkworms are being tried by farmers. Some of the new measures adopted have begun to show great promise in improving the farming pattern of silk production. It is expected that the whole structure of silk industry in Taiwan will be revived in the near future.

Improvement measures taken

A. Multiplication and extension of mulberry trees

Due to insufficient number of cultivated mulberry trees, most of the sericulture farmers used to collect the leaves of wild mulberry trees to feed silkworms. This unreliable source of feed supply accounted for the low unit yield of cocoons. To tackle this problem, JCRR rendered assistance to the Taiwan Sericulture Improvement Station (TSIS) in multiplying and distributing a total of 822,000 mulberry seedlings of the improved variety Taisong No. 1 to the sericulture farmers during the period FY 1966-69. The mulberry seedlings so far extended were mainly for the farmers to intensify the management of their mulberry farms through adopting a new pattern of silkworm rearing and to use cuttings for further multiplication. Meantime, five silk reeling plants also carried out mulberry planting work on their own, but no statistical data on the number of these seedlings distributed are available.

B. New practice of mulberry seedling multiplication

The application of the cutting method using mature branches to multiply mulberry seedlings has been practised for many generations in Taiwan. However, it was found recently that there are, at least, two disadvantages in using this method, i.e., it limits the leaf supply of mulberry trees due to the utilization of mature branches and it requires about one year for the seedlings to develop into the size suitable for planting. To cope with those drawbacks the new practice of semi-soft wood cutting, which was extended to the sericulture farmers for general adoption in Japan since 1963, was introduced into Taiwan in 1966. With JCRR assistance, TSIS has been conducting experiments using this method over the past two years to find out whether or not the procedures adopted in Japan needed to be modified under the prevailing conditions here. According to the results of these tests, a survival rate as high as 95% could be achieved from the cuttings. Furthermore, this new practice does not affect the mulberry leaf supply because it requires only 4-6 months to develop a good root system for transplanting. In 1968, the Hualien Farm of the Vocational Assistance Commission for Retired Servicemen (VACRS) was for the first time successful in using this method on a large scale by multiplying 200,000 mulberry seedlings in one season. Since then this new practice has been adopted by the local farmers for mulberry seedlings multiplication.

C. Mulberry breeding

In FY1970, JCRR supported TSIS in making a collection of biotypes of mulberry varieties from various parts of sericulture areas in Taiwan and to conduct a series of yield and adaptation tests. A total of 647 individual plants which had been subjected to a thorough test at the Tahu Sub-Station were collected from 36 townships early 1970. According to the results of observations made by the Station, some vegetative clones with desirable characters were found in the testing nursery. Since mulberry fields of the Island cover a wide range of soil and climatic conditions, a program is underway to send a part of the tested materials to the Chaochow Sub-Station for testing on their wide adaptability.

D. Demonstration of improved sericulture farming

Under JCRR assistance, a 3-year integrated demonstration project on sericulture farming at Paoshan Township, Hsinchu County, sponsored by TSIS was carried out from 1967 to 1969. A total of 10.5 ha of slopeland was planted to 62,000 mulberry seedlings by 40 farmers in the first two years, and they began raising silkworms in 1968. The number of egg sheets distributed and the cocoon production in the five crop seasons in 1968 and 1969 are as follows:

Year	Crop season	No. of egg sheets distributed	Cocoon yield per sheet (kg)	Total cocoon production (kg)
1968	Spring	34	24.47	831.90
	Late spring	5	17.64	88.20
	Summer	10	19.06	190.60
	Autumn	41.50	20.11	834.50
	Late autumn	8	30.21	241.70
	Total	98.50	22.20	2,186.90
1969	Spring	66	28.57	1,886
	Late spring	33.50	12.59*	421.90
	Summer	30.50	20.00	610.00
	Autumn	71	15.72**	116
	Late autumn	45	24.21	1,089.30
	Total	246	20.83	5,123.20

* Too much rain in the late spring season resulted in low yield.
** Two consecutive typhoons damaged mulberry leaves in the autumn season.

The average unit yield of cocoons in 1968 and 1969 was 21 kg per egg sheet, which was 55% higher than that of the check farms in the vicinity of the demonstration sites in the same period. Under this project the price of cocoons sold to the Miaoli Filature, TSC, was calculated on the basis of both the local silk price and the results of cocoon-quality testing. By this method, the price of cocoons was 60% higher than the pre-determined price offered by the four filatures. This demonstration set an example for the other silkworm raisers to adopt the intensive method of sericulture farming to raise the per hectare yield of cocoons and reduce the cost of silk production.

E. Introduction of modern knowledge in silk production

To help develop silk production, JCRR assisted the related agencies in strengthening their technical knowledge of sericulture farming by inviting two Japanese sericultural experts, Messrs. Y. Tokoro and T. Saitoh, to come to Taiwan in late March, 1969 for a one-month consultation; by conducting a 2-semester training course at the National Taiwan University to improve the technical level of 30 sericultural technicians from September 1969 to August 1970; by giving aid to TSIS in sending a technician to Japan to receive a two-month training on mulberry multiplication and cultivation under FY1969 Sino-Japanese Technical Cooperation program; and by sending an observation team of sericultural workers to Korea and Japan in May, 1970 on a 22-day study of sericultural farming projects in the two neighboring countries. All these activities proved very helpful to the implementation of sericultural production plan.

VACRS project for development of silk production

Starting 1967, VACRS set up a long-range silk production program for retired servicemen in Hualien and Taitung counties of eastern Taiwan. The production goal for the period from 1969 to 1972 is as follows:

Year	No. of mulberry seedlings to be multiplied	Acreage to be planted (ha)	No. of egg sheets to be distributed	Total output of cocoons (kg)	Production of raw silk (kg)
1969	1,000,000	100	500	10,000	1,250
1970	1,000,000	200	1,000	20,000	2,500
1971	1,000,000	200	2,000	40,000	5,000
1972	1,500,000	300	4,000	80,000	10,000
Total	4,500,000	800	7,500	150,000	18,750

A. Planting of mulberry trees

There are at present five VACRS farms engaged in silk production in eastern Taiwan. Among them, the Tailai Farm in Hualien and the Tungho Farm in Taitung take care of most of the mulberry acreage, while the Hualien Farm and the Taitung Farm concentrate on the multiplication of mulberry seedlings. In 1969, a total of 600,000 mulberry seedlings of the improved variety Taisong No. 1 were produced by these two farms and distributed to the other farms for general planting. The acreage of mulberry trees planted in the four farms in eastern Taiwan during the period from 1967 to 1969 is presented below:

		Tailai Farm	Tungho Farm	Taitung Farm	Chihpen Farm	Total
1967	No. of seedlings planted	179,978	121,103	—	—	301,081
	Planted acreage (ha)	56.00	48.40	—	—	104.40
1968	No. of seedlings planted	13,300	—	55,033	—	68,333
	Planted acreage (ha)	4.75	—	12.00	—	16.75
1969	No. of seedlings planted	121,105	187,324	62,302	5,000	375,731
	Planted acreage (ha)	32.54	46.83	8.75	0.50	88.62
Total	No. of seedlings planted	314,383	308,427	117,335	5,000	745,145
	Planted acreage (ha)	93.29	95.23	20.75	0.50	209.77

B. Silkworm rearing

In 1968 silkworm rearing was introduced on a small scale in the Tailai and Tungho Farms for the purpose of familiarizing the retired servicemen with the improved techniques of sericulture farming, so that they could perform better work in keeping with the 4-Year Plan beginning 1969. As expected the subsequent silkworm-rearing work done by the retired servicemen was a success. A total of 1,390 kg of raw silk was produced by the two farms in 1969 with an average unit yield of 23.5 kg of cocoons per egg sheet, which was 97% higher than the average output of the whole province during the same period. The credit for the high yield was mainly due to adequate supply of mulberry leaves to feed the silkworms, and available labor to take care of silkworm-raising work. However, unfortunately, some problems were encountered in the process of producing raw silk. As shown in the following table, the percentage of cocoon layer ratio was rather low, because it required 8.9 kg of cocoons to reel into one kg of raw silk, which was about 50% higher than the Japanese record. The cause of the low percentage of raw silk was possibly due to the inferior quality of silkworm variety used. The silkworm variety now in use for general raising in Taiwan was developed in 1953. Because of repeated inbreeding, it showed degenerated characters in both cocoon yield and cocoon quality. The records of 1969 silk production on the two farms are tabulated as follows:

	Tailai Farm	Tungho Farm	Total
No. of egg sheets distributed	279.5	238	517.5
Cocoon yield per sheet (kg)	22	25	—
Total cocoon production (kg)	6,149	5,950	12,099
Cocoon layer ratio (%)	18	18	—
Cocoons required for reeling one kg of raw silk (kg)	8.9	8.9	—
Total raw silk production (kg)	713	677	1,390

Prospects and future endeavors

Taiwan's natural environment is ideal for sericulture farming. In southern and eastern parts of the Island silkworm rearing can be raised to eight crops a year, a record which can never be attained by Japan or Korea. Here, it is also possible to raise silkworms in the gentle slopeland areas. In view of the shortage of raw silk supply in the world market, there is ample market to absorb the raw silk or silk piece goods produced in Taiwan. Thus, the prospect of developing silk production here is very promising.

For further development and remedy of the defects and shortcomings existing in the silk industry, concentrated efforts by all parties concerned to realize the following objectives are necessary:

1) At present, most of the mulberry farms in Taiwan are widely scattered on steep hillsides with slopes of 20° or more, thus accounting for the low yield of leaves. To improve this situation, the utilization of a part of cultivated land with gentle slopes and some old river beds should be considered. By so doing, not only capital investment in farm roads and irrigation facilities for setting up mulberry farms can be reduced to a minimum, but also both mulberry planting and silkworm raising can be mechanized simultaneously to save time and labor.

2) On the average, each farmer engaged in silkworm rearing in Taiwan only raises 2 egg sheets per crop, usually taking about 50 man-days to complete the process of silkworm raising in each crop season. Due to the fact that much labor is involved in sericultural farming, our silk production has been low all the time. To remedy this situation, it is important to increase the number of egg sheets raised by each farmer and discard the primitive production methods practiced locally to save a certain amount of labor which, in turn, reduces the cost of cocoon production.

3) Both the varieties of mulberry trees and silkworms now in use in Taiwan were developed long ago. In recent years, defects have been found in these varieties affecting the yield of mulberry leaves and cocoons as well as cocoon quality. Thus, the task of varietal improvement of both the mulberry trees and silkworms is an important consideration in the implementation of any silk production project. The line selection program for mulberry trees now being carried on by TSIS should be further strengthened. A large-scale introduction of silkworm strains from abroad and experiments on breeding are also urgently needed to increase production efficiency at an early date.

4) With our expansion and physical improvement of the silk industry, there is a mounting need of personnel trained in sericulture to cope with the various difficulties encountered. Since sericultural farming is a specialty work with which the average agricultural workers are not familiar, so a number of sericultural technicians have to be trained on improved techniques of mulberry planting and silkworm raising, to enable them to teach other technicians to meet the requirements of the production plan.

5) The mulberry tree is one of the perennial crops that takes a long time to grow maturity. In general, farmers do not attempt to raise silkworms in the first year or two after the mulberry trees are planted. Thus their investments would bring returns only from the third year on. This is one of the reasons why silk production has remained low. This problem can be solved if long-term, low-interest loans are available to ease the burden of silkworm growers.

RESEARCH AND EXPERIMENT ON SOILS AND FERTILIZERS FOR RICE CULTIVATION IN TAIWAN

Nan-Rong Su

Physico-chemical conditions of paddy soils

Physico-chemical properties of latosolic paddy soils were investigated with particular reference to their productivity. High yielding paddies of red soil area were found to have such characteristics as high hydraulic conductivity, high available N and P and low exchangeable Al contents.

In the recent studies of latosol and sandstone/shale alluvial soils, it was observed that the soil solutions of low-yielding paddies always contain high bicarbonate ions. Sometimes, low contents of available nutrients such as P and K (combined with high Ca, Mg) were also associated with low productivity.

Acidity of paddy soils was investigated in connection with the Al and Fe status of soils, lime potential and corrected lime potential. It was found that the lime potential is a better index of lime requirement than the pH value. For rice, however, it was observed that the Ca status of the soil was at an optimum when the Ca saturation reached 8-20% of the exchange capacity. A sharp decline in yield was observed above this optimum.

Changes in the reduction-oxidation potential of submerged soils were studied in relation to the occurrence of "suffocation disease" of rice, availability of native and applied phosphorus as well as the solubility of Fe and other elements. Organic matter in fresh form accelerates reduction of the paddy soil and enhances the availability of P, but aggravates the physiological disorder of the rice plant. Periodical surface draining of paddy field appeared to be most effective in controlling such disorder. Oxidation of the soil with chemicals such as manganese dioxide and iron hydroxide was also effective to a considerable extent.

The influence of percolation rate of water on rice growth was assayed in pot experiments with two silt loams. The optimum rate was found to be 3-5 cm per day for Taipei soil with a 38-67% yield increase in comparison with no-percolation and 1 cm per day for Changhua soil with a 3-33% yield increase.

Microbiology of paddy soils

In the microbial studies of poorly-drained paddy fields, it was found that all soils produced growth-inhibiting substances of variable nature when subjected to continuous submersion.

Previous research revealed that the physiological disorder of the rice plant in the Lotung area was associated with phyto-toxic substances produced by nitrate-reducing bacteria, *Pseudomonas*, or by the decomposition of organic matters themselves; 18 species and strains were isolated from the root zone. Recent studies dealt with the relation of productivity of paddy soil to soil microflora and organic decomposition products. Low yielding soils were found to have a high population of *Pseudomonas*, but the contents of toxic compounds like phenolic acids were not consistently related to yield levels. The growth of blue-green algae was reversely correlated with rice growth.

Soil fertility of paddy fields

Strongly acid soils with pH values below 5.6 constitute about 1/3 of the cultivated acreage in Taiwan. Early trials indicated that the application of lime on acid soils was effective in increasing rice yield, whereas recent field experiments on latosolic paddies using various forms of lime did not generally support this conclusion. Only some of the fields newly submerged for rice growing showed response to liming. However, in a recent pot experiment using a latosol from Chungli, the application of an optimum amount of calcium carbonate brought about an immediate remarkable effect and an even higher residual effect on rice yield. A parallel examination of soil water revealed a significant lowering of Fe and Mn concentrations in the limed pots.

In the investigation of major nutrients in the soil, as affected by continuous rice cropping, it was found that the rate of depletion of available NPK was faster in the latosol than in the alluvial soils.

Potassium fixation was found to be appreciable in the alkaline slate alluvial soils, weak in the sandstone and shale alluvial soils and very weak in the latosols.

Under paddy conditions, the phosphate applied is gradually transformed into iron phosphate, and crystalline forms of soil phosphate are transformed into colloidal forms. Availability of soil phosphorus is noticeably enhanced after submergence.

Research was carried ont on the transformation of nitrogen in the paddy. Leaching loss of nutrients was studied for different soils in a lysimeter experiment. The average leaching loss per ha per crop was: Ca, 213 kg; Mg, 76 kg; K, 22 kg; N, 13 kg; and P, 0.7 kg.

In the latosols newly submerged for rice culture, pH was found to have risen from 4.4 to 5.6, while available P, K and Si markedly increased in 4-5 years with the values gradually approaching those of the average old paddy soils. No change in total N, organic matter and cation exchange capacity was noticed.

The cultivation of green manure, vegetables or sweet potatoes as winter crops is conducive to raising the fertility of paddy soils. Also the multiple cropping system with proper fertilizer application improves soil fertility.

For the newly submerged latosolic paddies in Taoyuan Prefecture, the effect of the heavy rate of P_2O_5 up to 150 kg per ha was spectacular (yield increase averaged 53%). When, in addition to heavy phosphate fertilization, compost and silicate slag (or lime) were applied, the grain yield could be increased by an average of 80%, to 5.2 tons per ha, which is the normal yield level for old paddies. In a greenhouse study it was observed that though both compost and lime were independently effective in improving the rice yield in latosol, their simultaneous application remarkably reduced the effect.

A study of correlations between fertilizer response of rice and the levels of soil available P and K was conducted during 1960-64. It was found that, for all the three major groups of rice soils, the critical concentrations of available P and K were 20 ppm (Bray No. 1) and 45 ppm (Mehlich) per ha, respectively. For latosols, the critical concentration of exchangeable K was 70 ppm. Four levels each of P and K fertilizer were recommended for various levels of available P and K in soil. About 40% each of the paddy soils in Taiwan is definitely deficient in P and K (i.e., very low or low). As a whole, soils in Ilan, Changhua, Pingtung and Hualien are particularly deficient in K, while the lowest P is found in Taoyuan. In fact, the fertility status of soils is heterogeneous even in the same area. In 1966-68, the critical concentrations of soil available P and K were re-evaluated for soils in northern Taiwan (north of Taichung) by establishing 109 observation plots, markedly higher values than those found in the 1960-64 experiments were obtained.

Nutrition and physiology of rice plant

It was found that nutrient absorption of rice can be increased by higher temperature, although this did not always result in increased grain yield. Varietal differences in nutrient absorption were large. Dwarf *indica* varieties absorbed more per ha and per ton of grain, producing more grain as compared with the *japonica* varieties. Nutrient absorption was greater in the 1st crop than in the 2nd crop, due to higher yield in the former. Concentration of N in straw was lower and that of K higher in the 1st crop than in the 2nd crop.

Nutritional characters of rice plant in the poorly-drained paddies were studied. Plants injured by physiological disorders under such conditions were low in K and P and high in N, Fe and Mn, as reported by TARI. According to the experiment conducted by the Provincial pingtung Junior College of Agriculture, rice plants grown under poor drainage conditions were low in Si, Fe, Mg and p contents, high in Mn, but with similar N and K contents, as compared with those grown under good drainage conditions.

The cause of the low yield in the 2nd crop of rice, as compared with that of the 1st crop, was investigated for the pingtung area. The main problem seemed to be firstly in the decreased leaf area index, for which high respiration loss and potassium deficiency, aggravated by high carbonic acid in soil water and high soil Ca supply, were responsible; and secondly in the lower net assimilation rate in this crop season during ripening stage, for which lower solar radiation and morphologically inferior light-receiving posture of the plant were responsible. The variety IR-8 in comparison with Chianan 8 was found to possess both higher leaf area index and better light receiving system thus resulting in higher yield.

The critical concentration of K in the above-ground part of the rice plant was found to be 1.7-1.8%, based on extensive field trials in the Taoyuan area. Similar research was carried out for N with a view to establishing an index for crop log of rice. The result was inconsistent in different years and crop seasons. Another research, however, showed that there existed a good correlation between the response to panicle fertilizer and the N content of plant at panicle initiation stage; 1.8-1.9% N was the critical level observed. The N content was also correlated with iodine reaction of sheath as well as leaf color intensity of center leaves.

In regard to nutritional characters of rice plant at different yield levels, it was found that the high-yield plants contained higher N and P at early growth stage and higher P at mid-stage as compared with the low-yield plants. In the case of the 1st crop, the N level in plant at mid-stage was lower in the high-yield plots than in the low-yield plots. Uptake and translocation of P was examined under variable conditions of nutrient supply and in relation to the stage of growth.

Recently the physiological disorder of rice in Hualien was found to be caused by zinc deficiency. More research will be conducted to devise a method to correct the disorder.

Study of fertilizer use for rice

1. Nutrient requirements:

The requirements of rice for N, P and K have been found to vary considerably according to locality, variety, soil fertility status, drainage conditions, crop season and plant spacing. Recently some heavily tillering varieties of the dwarf type (*indica*) were found to respond to increased N dosage up to 125-150 kg per ha or even higher, whereas the average *japonica* varieties required 80-120 kg, and the tall *indica* varieties usually could not tolerate N application in excess of 80-90 kg per ha. The effect of increasing the N rate from 80 to 120 kg was negatively correlated with the height of variety. Nitrogen requirement is lower for high plant densities than for low densities.

The effect of added K was more pronounced in the poorly-drained areas of Pingtung and Ilan than in the red soil area of Taoyuan, which had been considered the most K-responsive area before. Up to 80-100 kg of K_2O per ha were found to be more profitable than the lower rates in many localities in these areas. In average soils, the K_2O requirements of rice ranged from 30 to 60 kg per ha. Varietal difference in K response of rice was found to be inconsistent, although some tests revealed that *japonica* varieties were more responsive, as compared with the *indica* varieties while others showed that the number of grains per panicle was positively related to the extent of K response.

Phosphate was effective especially on the latosolic paddies, poorly-drained plain of Ilan and some other P-deficient soils scattered in various localities. An exceptionally heavy rate of P_2O_5, e.g., 150 kg per ha, was necessary to meet the requirement of rice in the newly submerged paddies of latosolic tableland in Taoyuan. A low-yield paddy in Miaoli (sandstone/shale alluvial soil) could be changed into high-yield paddy by raising the P_2O_5 rate to 120 kg per ha. For ordinary paddies, 30 to 60 kg per ha of P_2O_5 were sufficient to meet the rice requirement. It was also found that the decrease in rice yield after deep plowing was attributable to the drop of available P in surface soil, and that heavy application of P was effective in this case.

The importance of nitrogen application at an optimum rate to rice nursery was established for all localities. Optimum N rate from the standpoint of final grain yield was 50 g/3.3 M^2 or lower in the first crop and 25 g/3.3 m^2 or less in the second crop. In general, the rate should be higher in the north than in the south. The effect of P and K applications to the nursery on yield was significant in 70 percent of the experiments.

2. Source of nutrient:

Field experiments and numerous demonstrations have shown that ammonium sulfate and urea are equally satisfactory as nitrogen source for rice if optimum amounts are used. The optimum rate of N is somewhat higher for urea than for ammonium sulfate, but the net gain is in favor of urea because of cost difference. Nitrate form of nitrogen is always much inferior to the other sources under paddy condition.

In the latosolic paddies, rock phosphate is inferior to regular superphosphate, when compared at the regular range of dosage, but when the P_2O_5 rate is raised to 320 kg per ha, rock phosphate has been proved satisfactory. Besides, its residual effect is very high.

Sources of potash have been compared only on the salt-affected soil in the coastal area of Taiwan. On such soil, there is an indication that the sulfate form is better than the chloride form.

3. Method of fertilizer application:

Field trials on the techniques of fertilizer application, especially for N and K, were extensively conducted in the past few years. For both the light and heavy soils, N application was found not only necessary at the early stages but also particularly indispensable at the 2nd weeding stage and panicle initiation stage. Recent trials showed that relatively heavy dressing of nitrogen was needed at the 2nd weeding stage in the south and in the 2nd crop in the north, but lighter application of nitrogen or depletion of nitrogen at the same stage and deficit supplement at the full heading stage was better in the 1st crop of northern Taiwan.

Timing of nitrogen application at the reproductive stage of growth and the method of diagnosing nitrogen need at this stage have been studied in recent years. "Panicle fertilizer" gave variable effects, depending on the time of application. For the 1st crop it was found that for all parts of Taiwan, panicle fertilizer should be applied 20 to 25 days before heading when the length of young panicle was 2 mm or just before its emergence. The necessity of this application can be indicated by a starch test of the sheath of the 3rd unfurled leaf.

For direct-sowing culture of rice, nitrogen should be applied at 3-4 stages including the panicle initiation stage, and the amount of basal fertilizer could be small.

The rate of N and the methods of split application of N were investigated for the excessively percolated soils. In northern Taiwan 150 kg per ha of N are required, while in central, southern and eastern Taiwan, the optimal rates exceed 180 kg per ha. Nitrogen should be divided into 4 to 7 doses, depending on localities, and applied from the time of recovery of seedlings up to panicle initiation or even later. Application in band near the plant row during the early stage of growth showed good results.

Potash should, for the best result, be divided into two to three doses and a large proportion applied at the 2nd weeding stage. The effect of divided application of potash is particularly great in the poorly drained soil of Ilan.

Divided application of superphosphate into 2 to 3 dosages has also been found to produce higher yield than the mere basal application in the experiments conducted in Ilan recently.

4. Nutrients other than NPK:

Magnesium was tested on several soils in northern, central and southern Taiwan, but cases of response to this nutrient were few.

The effect of manganese, iron, zinc, copper and boron was not significant in the seven trials in northern, central and southern Taiwan. But Zn deficiency has recently been found to occur in the Hualien area.

Effects of soil amendments, such as silicic slag, fly ash, silica iron, zeolite, temporon, etc., have been examined in various localities. Significant responses to silicic slag, silica iron and temporon were noted.

Silica is effective in acid soils with low available silica contents. In general, rice will respond to the application of silica when available SiO_2 (extracted by NaAc at pH 4.0) in soil is below 45 ppm. Critical concentration of SiO_2 in straw is about 9%. In some latosols, especially the newly submerged poddies, the yield increase may exceed 10%.

Varietal differences in response to silica were manifest. Hsinchu 56 and Taichung 65 gave the highest response, followed by Taichung Sen 2 and Tainan 5, while Ai-chiao-chien showed almost no response.

5. Slow-release nitrogen fertilizer and nitrification inhibitor:

Ureaform and CDU were tested by various research institutions on rice in average paddy fields and sandy soils, but so far with little success. Generally, divided application of ammonium sulfate done in a conventional way gave better results as compared to the use of slow-release nitrogen compounds. Ureaform appeared to be better than CDU under paddy conditions.

The nitrification inhibitor, AM, seems to be effective in the 1st crop in increasing the effect of nitrogen fertilizer.

6. Nitrogen and quality of rice:

It was found that the crude protein content of rice could be increased significantly by augmenting nitrogen dosage from 80 kg to 120 and 160 kg per ha, especially when a part of N is used as panicle fertilizer. In this case, however, the digestibility of rice is reduced, and to counteract this reduction of digestibility cooking time must be prolonged.

DETAILED SOIL SURVEY OF CROPLAND IN TAIWAN

Shin-Tuan Wang

The most valuable national asset in any country is its soil. If soil is well managed, its fertility is not only renewable but improvable, otherwise the soil can be permanently damaged or irretrievably lost. It is well known that crops differ markedly in their adaptation to climatic conditions. However, within any climatic region, there is a wide variation in the suitability of soil conditions to which the same group of crops must be adapted. Therefore, the successful production of crops, in both quantity and quality requires an intimate knowledge of the soil as well as the crop being grown. We must have precise information about the geographical extent and location of various soils and then determine how they can best be used and, at the same time, conserved for posterity. Such scientific and practical knowledge can only be secured through detailed soil surveys—primarily to map and classify the soil in the field.

Through years of improvement, Taiwan's agriculture has now reached a point where the per-hectare yield can no longer be boosted significantly and economically with such simple treatments as the use of chemical fertilizers or pest control measures. What we need is a rational combination of all related scientific techniques in regard to soil and crop management. We must have more specific and precise knowledge about soil and crop relationship, and know what kinds of soils we have, where they are located, how to use them wisely and treat them properly, how they respond to fertilizer applications both qualitatively and quantitatively, what the most adaptable crop varieties are as well as the cropping systems for various soils, and also the problems pertaining to irrigation and drainage practices. To tackle these problems and to fit all crop production measures into the soil conditions so as to achieve still more efficient land use, the task of producing a detailed soil survey map was deemed necessary.

In the last two decades, both reconnaissance and semi-detailed soil surveys have been carried out by organizations concerned, and the results obtained have contributed a great deal to an understanding of the general properties and approximate distributions of important soils. However, the information obtained from these surveys can no longer fulfill the demand for further diversification in agricultural production and development of proper management practices for crops according to the properties of soils. Furthermore, as most of the surveys were done separately by various organizations to serve their own interests without regard to work coordination, there appear many gaps and inconsistencies which have made correlation and grouping of mapping units of the different maps almost impossible.

In 1963, JCRR initiated a long-term project for a detailed soil survey to classify and map the agricultural soils of Taiwan. The project was sponsored by the Provincial Department of Agriculture and Forestry with the Provincial Chung Hsing University as the executing agency. The field work of soil mapping and laboratory study of soil properties were completed at the end of 1970, and the soil maps and survey reports once compiled will be published in 1971.

Under this program, some 570,000 ha of cropland south of the Ta-an River embracing the 8 counties of Taichung, Nantou, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung and Pingtung were surveyed and mapped. Soils of the surveyed area are all distributed on alluvial plains and low terrace tableland mostly cultivated to paddy rice or under the 3-year rotation cropping system including paddy rice, sugarcane and sweet potatoes. Some 300 soil series have been defined and more than 4,000 soil samples collected from representative soils for laboratory studies of their physical and chemical properties. The information obtained has been compiled into 85 sheets of detailed soil maps and 7 volumes of survey reports for the respective areas.

The results of a soil survey are of little use until they are made meaningful to the many prospective users of soil maps who are not acquainted with the terminology or symbols of soils, and who do not know how to interpret the soil survey data. To make the survey results easily understood for use by organizations and individuals for a wide variety of purposes, the survey method adopted and the use of soil survey results are described as follows.

Method adopted

A. Soil classification:

As the criteria of classification of alluvial soils, especially for paddy soils, are still under discussion, much attention has been paid to the categories lower than the soil series. For the convenience of abstracting similar soil series, soils derived from similar origin or mode of deposit are grouped tentatively in a group and subdivided according to differentiating characteristics such as lime concretion, calcareous or other particular diagnostic soil horizons or layers in the profiles. Since these soil groups are tentative ones designed to meet present needs for field mapping of soils, they are subject to modification as soon as a proper classification system for alluvial soils is approved. It is not expected that serious trouble would be encountered in the regrouping of soil series at higher categories if the preliminary soil series have been clearly defined.

1) Soil series:

Soils having similar profile characteristics other than texture of the surface horizon are put in the same series. The soil series is given the geographic name where the soil was first found. In defining soil series, texture profile and natural drainage of the soil constitute the important differentiating characteristics for the soils derived from similar parent material or mode of deposit. A broader range of texture in the lower part (90-150 cm) of the subsoil is usually allowed than in the upper part (20-90 cm). Natural drainage is divided into three classes, i.e., well to moderately well, imperfect and poor as judged by the pattern of mottling and color of subsoils, and/or location of ground water level if found. An example showing the key to soil series is presented as follows:

A Key to Alluvial Soils in Changhua Area

Texture profile		Slate recent alluvial soils			Slate older alluvial soils		
20-90 cm	90-150 cm	Well to mod. well	Imperfect	Poor	Well to mod. well	Imperfect	Poor
Sicl			Li			Lu	Si
Sil—L		Te	Es	Wk	Ph	Eh	Sh
Sl/Sil			Tl		Yl	Ty	
Sil/Sl—Ls			Wa	Mc	Ls	Yu	
Sl—Lfs		Sw	Ts		Kk	Kh	

Note: Symbols and names of soil series:

Symbol	Name		Symbol	Name	
Es	Erh-shui	(二　水)	Kh	Kuan-yu-tseu	(管嶼厝)
Li	Lien-hua-chih	(蓮花池)	Kk	Kung-kuan	(公　館)
Mc	Mien-chien-tseu	(面前厝)	Lu	Luh-kang	(鹿　港)
Sw	Shui-wei	(水　尾)	Ls	Lu-shang-tseu	(路上厝)
Te	Tien-chung	(田　中)	Ph	Ping-ho	(平　和)
Tl	Tsen-tseu-lun	(曾厝崙)	Si	Shiu-shui	(秀　水)
Ts	Tsao-yang-tseu	(潮洋厝)	Sh	Sheh-tou	(社　頭)
Wa	Wan-ho	(萬　合)	Ty	Tien-chung-yang	(田中央)
Wk	Wai-san-kuai	(外三塊)	Yl	Yu-liao	(魚　寮)
Eh	Erh-lin	(二　林)	Yu	Yuan-lin	(員　林)

2) Soil type:

The soil type, a subdivision of soil series, is based on the texture of surface soils. The following groups of textual classes are usually divided into different types within the series when differences occur within the plow layer. Symbols of texture class follow those of soil series.

Class symbol	Texture of plow layers
0	Coarse sand and sand
1	Fine sand, loamy coarse sand and loamy sand
2	Loamy fine sand, coarse sandy loam, sandy loam and fine sandy loam
3	Loamy very fine sand, very fine sand and very fine sandy loam
4	Silt and silt loam
5	Loam
6	Sandy clay loam
7	Clay loam and silty clay loam
8	Silty clay
9	Clay

3) Soil phase:

For practical use or soil management, soil phases are defined within a soil type according to salinity and stoniness of the surface soils and steepness of land slope. Symbols of the respective phases follow those of soil type.

B. Field mapping:

1) Base map:

Cadastral maps on the scale of 1:4,800 or 1:5,000 are used as base maps for field mapping.

2) Examination of soils and plotting of soil boundaries:

Soils are examined to the depth of 150 cm or less with a post hole auger at a distance of every 200 meters and identified according to their characteristics defined in the criteria of soil classification.

Soil boundaries are plotted on the base maps according to the results of soil examination and landscape.

3) Mapping unit:

In general, toxanomic unit of soils, such as soil type or phase, is used as a mapping unit where the proportion of the defined soil constitutes more than 85% of the total area of the unit. Where the distribution of the soil is too complicated to be separated into a single unit, soil complex or miscellaneous land type is used. Due to the problem of cartographic detail, soils of areas less than 1.5 ha are usually not shown on the map.

C Field study of soils:

In preparing soil descriptive legends and after finishing field mapping of soils in an area, detailed soil profile studies and descriptions are made for typical profiles of each soil series. In the course of field mapping, soil profile descriptions are also made by field men whenever soils are found to differ in characteristics from those described in soil legends; and micro monoliths of soil profiles are taken for correlation of the soils. In describing soil profile characteristics, each soil horizon or layer in the profile is carefully recorded by following the procedure proposed by USDA.

Items included in soil profile descriptions are: 1) color, 2) texture, 3) structure, 4) consistence, 5) reaction, 6) organic matter and plant roots distribution, and 7) special formation (concretions, pans, etc.) of each soil horizon. Besides the description of soil profile, land features, drainage conditions, parent materials of soils and land use are also studied in the field.

D. Laboratory study:

To provide data on the fundamental properties of soils for further study of the genesis of soils as well as for the study of relationship among soils, the following items of physical and chemical analyses are carried out on soil samples collected from each horizon in profiles of main soil series: 1) particle size distribution, 2) soil reaction, 3) organic matter content, 4) calcium content, 5) cation exchange capacity, 6) base saturation, and 7) free iron content.

E. Preparation of soil maps and survey reports:

1) Soil maps:

Field sheets of soil map on the scale of 1:5,000 or 1:4,800 are first compiled into manuscript maps on the scale of 1:25,000 and then transferred on to the same scaled topographic maps to be printed in three colors. On the published soil maps, soil phases or soil types are shown as mapping units with specific symbols. The extent of each unit is accurately delineated on the map with specific soil boundaries in relation to other prominent physical and cultural features of the earth's surface.

2) Soil survey reports:

To make all the specific information about each kind of soil significant to its use and behavior, and to provide such descriptions of the mapping units so that the survey data can be interpreted for land use requiring fundamental facts about soils, the results obtained from both field and laboratory studies are compiled into seven volumes of survey reports for the respective areas. The topics included in the report are:

a) Use of soil map and report
b) Survey method
c) A general description of the area
d) Formation and classification of soils
e) Distribution of the soils
f) Use and management of the soils
g) Description of the soils
h) Tables of analytical data of soil properties

Use of the survey results

As the soil survey results provide basic information on the character and distribution of various soils in an area, they may be used in any field which requires information about soils. For agricultural use, the soil survey data can be used as a basis for further research in soil properties, soil-crop-management relationships and for selection of site for field experiment as well as for analysis of the results of such field experiments. Soil survey information can also serve as a vehicle to bring the results of research and experiments back to the field where they apply. For example, it can be used in the choice of crops or land-use, in crop management practice, in land classification and land evaluation and in soil management and land reclamation. It is generally true that the results of field experiments can not be used to the greatest possible advantage without the aid of a detailed soil map.

Furthermore, as the final result of a soil survey is a comprehensive inventory of soil resources of the country, such an inventory, together with climate data and other information, can be used by the administrators for a wide variety of purposes. In determining overall agricultural policy, it may be used to show potential productivity of a country, delineate problem areas, indicate where and how production can be increased, and estimate fertilizer requirements.

Work to be done for making full use of survey results

The usefulness of soil survey information is entirely dependent upon interpretations which require the combined knowledge of soil properties, qualities and behavior so that the soil map users can make intelligent choice among alternative uses and combinations of those practices related to soil conditions. For agricultural use, the knowledge of the characteristics of individual soils in relation to their effect on plant growth and combination of farming practices is necessary for better interpretation of soil survey data. This knowledge may be gained form basic soil investigations, data from experimental fields and accumulated farm records. At present, this much needed knowledge is still not enough for a proper interpretation of soil survey in Taiwan. The following work should be carried out in order to make full use of the results of this survey.

A. Study on soil-crop-management relationships using main identified soils:

Although in the past decades, a great deal of research and field experiments have been carried out on soil properties and crops management, but few have been carried out on the relationship between soils and crops as well as on the response of soil to management practices. In interpreting the soil survey data for practical use, information on this aspect is still not enough. The results of this study will provide information required for the selection of suitable soils for crops as well as in developing proper management practices according to soil properties with the aid of soil maps.

This study has already been initiated in 1970 under JCRR support.

B. Interpretation of data obtained in previous crop and fertilizer experiments:

In previous experiments, the properties of soils of the trial plots were usually not described in detail. It is difficult to apply the experimental results accurately to farm lands, because we do not know under what soil conditions the results were obtained. Only after making examination of the soil conditions of each plot, are we able to correlate experimental results with soil conditions, to render the results of field experiments applicable to other fields with similar soil conditions.

C. Preparation of soil association maps of cropland for agricultural use:

To provide generalized, systematic information on soil resources as well as potential productivity of the area, detailed soil maps may be compiled into soil association maps by regrouping soil mapping units according to their soil properties significant to crop production and management practices and other land conditions related to the use of agricultural land.

D. Establishment of a standard for soil description of experimental plots:

The interpretation of soil survey data requires comprehensive knowledge of field experiments which have been carried out under different soil conditions. To make use of soil information obtained from various experimental plots comparable with one another, a standard or a manual describing the soils in the field should be made available to soil men responsible for field experiments.

E. Training of soil men in the interpretation of soil survey data and identification of soils in the field:

To make use of the results obtained from field experiments to the greatest advantage with the aid of a detailed soil map, soil men who are responsible for the experiments need to be trained in the interpretation of soil survey data and in identification of the soils as described in the various experiments.

In closing this report I wish to point out that in order to cope with the present demand for further diversification of agricultural production, and for better utilization of limited land resources so as to make farming yield higher profits, the selection of suitable soils for crops and the development of proper management practices according to soil properties are of special importance. Whatever benefits derived from the soil survey will serve as one of the most useful means to attain this purpose.

LAND AND LAND-USE IN ABORIGINAL RESERVATIONS OF TAIWAN

Lien-Chi Hsi

Historical Background

The history of the aboriginal reservations in Taiwan can be traced back to the early part of the Ching Dynasty. Before 1661-62 when Cheng Chen-kung, known to the Occidentals as Koxinga, moved his regiment headquarters to Taiwan and used it as a base against the Manchus, the whole Island was then inhabited by a few tens of thousands of indigenous people. In attempting to restore the Ming Dynasty without any revenue or financial support, Cheng adopted the camp and farming system by letting the military colonists till the land around their camp sites. In the following years, large numbers of Chinese who did not want to be ruled by the Manchus migrated to the Island from Fukien and Kwangtung. It was only natural that the impact of succeeding tides of such aggressive, land-hungry immigrants resulted in large-scale dispossession of land of the original occupants who held or claimed large areas under non-intensive cultivation. The increasing movement of population toward inland areas had forced the aborigines to retreat gradually to the hillsides and then deep into the mountains. Conflicts between the lowlanders and the aborigines became more and more serious, sometimes ending in bloody reprisals.

To temper their disputes over land holdings, the imperial Court of the Ching Dynasty enacted in 1725 a land-lease system permitting the lowlanders to lease land from the aborigines. This arrangement was tantamount to recognizing officially the *de facto* rights of the aborigines' pre-occupancy of the land. Meanwhile, the lowlanders, taking advantage of this system, moved on into the hilly regions at an accelerated pace. The aborigines were cheated in land transactions, because land to them was not a commodity to be bought and sold for profit. The lease system eventually became a device for transferring aboriginal land to the lowland settlers, thus threatening the very livelihood of the indigenous people. Two years later, the Viceroy of Taiwan set up a boundary for each aboriginal village and reserved the land within the village boundary (about 500, 400 and 300 hectares each for large, medium and small villages, respectively) for use by the villagers only. This could be considered the beginning of aboriginal reservations in Taiwan.

During the early days of Japanese occupation (1895-1945), one of the major agricultural programs was to make an overall inventory of national forests. The farming activities of the aborigines were limited only to certain areas designated as "lands for indigenous people", i.e., farm and forest lands encircling the aboriginal villages, totalling some 450,000 ha. In 1925, the Taiwan Governor-General's Office launched a 10-year forest program. An operation guidance for the forest industry in Taiwan was promulgated in 1928, which divided national forest land into three categories, viz., reserved, quasi-reserved, and unreserved forest lands. The reserved forest (now the national forest division) was put under the direct Government management, and the quasi-reserved forest corresponded to "land needed for aborigines", but with the area further reduced to about a quarter million hectares, after allocation having been fixed on the basis of 3 hectares per person. This classification served as the pattern for today's national forest land program, with the Chinese Government adopting practically the same administration system after Taiwan's Retrocession.

In 1948, the Provincial Government of Taiwan proclaimed the regulations governing the administration of aboriginal reservations and authorized the Provincial Department of Civil Affairs to be responsible for their implementation. The regulations stated clearly that the reservations designate the national land and all the immovable fixtures thereon set apart to ensure the livelihood of the aborigines during Japanese occupation. These lands are protected against alienation and encumbrance, and are exempt from national and local taxation. The aborigines may make use of and reap crop products from the lands, but are not allowed to manipulate the titles to them.

Land Utilization - a Century Old Problem

Taiwan's aborigines, like the indigenous people in many other countries, are fatalistic and easy-going. They do not have any idea of protecting property interests, and they are not inclined to follow the agricultural pursuits of lowland settlers. Shifting cultivation has been widely practiced on steep slopes with very primitive tools and cultural methods for many years. As the population grew, it became necessary to lengthen the cropping part of the shifting cycle unduly, thus shortening the fallow period to allow regeneration of soil fertility, which, in turn, resulted not only in the rapid deterioration of the hillsides, but also caused frequent disasters to the downstream areas.

The management and proper use of reservation land has long been a much-debated, controversial issue among the politicians and agriculturists as well as the economists concerned with the future development of Taiwan. Many complained that the vast reservations were a waste of the Island's limited resources. They advocated the abolition of the system and the release of reservation to all eligible investors for development. Some friends of the aborigines believed that the only way the aboriginal people could appreciate and intensify the use of their land was for each family to have a freehold of the reserved land it uses so as to become independent owner-farmers.

It would be relatively simple if the responsibility could be discharged by the judicious determination of the competency of the aborigines to manage their business affairs thereby ending the trust status. But the fact remains that it has been tried and failed. In 1915, while the Japanese Colonial Government was investigating and reorganizing the national forests of east Taiwan, lands then used by lowland aborigines were also surveyed and later allotted to the occupiers and recognized as private lands, therefore not included in the reservation (the so-called quasi-reserved forest) land. Since then, the area of aboriginal freeholdings has shrunk to practically nil. With this painful experience, the government agency (PDCA) charged with the responsibility of ensuring a stable living for the aborigines became rather reluctant to take any action which would change the trust status abruptly.

After careful studies and lengthy discussions with all the agencies and persons concerned, including many field inspections and island-wide inquiries, PDCA recommended and the Provincial Government adopted a three-pronged approach in an attempt to rationalize land use in the reservations.

A. Cadastral and physical survey of reservation land:

An overall cadastral and land-use survey of the aboriginal reservations was carried out by the Taiwan Land Bureau in 1958 through 1967. The total cost for the survey and mapping (excluding compilation) amounted to some 50,000,000 New Taiwan Dollars. Results of the physical survey are summarized in Tables 1-4, which will be discussed later.

B. Revision of administrative policy and regulations:

The revised Regulations Governing the Administration of Aboriginal Reservations in Taiwan was formally proclaimed by the Taiwan Provincial Government on January 5, 1966. Highlights of these revised regulations include the following:

Article 4: The Provincial Department of Civil Affairs shall be the Office in charge of the administra tion of aboriginal reservations, and the Hsien governments and township offices in the respective areas act as the executing agencies.

Article 7: After completion of the cadastral survey, the aborigines shall be entitled to apply for the following privileges for the land that they are using:

(1) Registration of farming right on arable land. After 10-years of continuous cultivation, the operator shall acquire the title to the land free. During the

first 8-year period, the land will be exempt from rental and taxation.

(2) Registration of superficies on a building site for continued use of the lot free of charge. The land shall be transferred to the occupant's ownership along with the farm land after 10 years when the "hold in fee" is issued.

(3) & (4) Lease of forest and grazing land in accordance with the existing regulations and procedures.

Article 9: Hsien governments shall determine the permissible acreage to be allotted to each person based upon the man-land ratios in their respective areas but not exceeding the standard range as approved by the Central Government, i.e., 0.2 to 0.4 ha of paddy field or 0.4 to 0.8 ha of dry-land, and 1.0 ha of forest land.

Article 25: Land-use survey should be carried out simultaneously with cadastral mapping to determine and delineate the areas which are (1) suitable for development, (2) unsuitable for development, and (3) suitable only for limited development. All the reserved lands shall be classified according to their capabilities into arable, pastoral and forest land categories which will be used and managed accordingly in line with soil conservation requirements.

Article 26: Plans for the improvement of occupied lands and the development of non-occupied but developable areas shall be worked out by PDAF, in cooperation with PDCA, and implemented step by step by the local governments.

Article 28: Undeveloped lands in the reservations, except that part which must be reserved for public use, shall be released for use according to the development plans mentioned in Article 26 under the following conditions:

(1) Those aborigines who live nearby but are using less land than the permissible acreage (Article 9) may apply for preferential allocation or lease of more land for cultivation or treeplanting.

(2) Reservation land not required for allocation and necessary public reserves may be leased to eligible enterprises or lowlanders. But arable land should first be leased to those lowland farmers who live in the aboriginal regions, who still do not have or have insufficient land for their own use.

C. Land-use adjustment and agricultural improvement:

Upon announcement of the regulations, PDCA and PDAF jointly mapped out a seven-year plan for their enforcement to promote proper, intensified utilization of reservation land with the ultimate goal of conserving the nation's vital natural resources and enabling the aborigines to become independent farmers. The major programs for attaining these goals are:

1. Land registration, allotment and lease:
   a. Registration of farming right and superficies on lands as applied by the aboriginal occupants for continued use.
   b. Examination and appraisal of land grading of each plot.
   c. Allotment of arable land to each family in accordance with Articles 7 and 9 of the Regulations.
   d. Lease of forest and grazing lands (renewable every 10 years).
2. Soil conservation: All the farm land with slopes of over 3% must be treated with erosion-control measures before the "hold in fee" can be issued. The total area to be thus treated has been estimated at 35,000 ha.
3. Land-use adjustment and reforestation: Reservation land which has been cultivated beyond its capability, totalling 34,000 ha, will be put back to forest.
4. Agricultural improvement through experimentation, demonstration, education and extension.

Land Features and Land-Use Conditions

When the Japanese Colonial Government enacted its forest program for Taiwan in 1928, all the lands with better forest stands were designated as "reserved forest". The "quasi-reserved" and "unreserved" forest lands represented only those denuded areas of non-economic forest lands. It is, therefore, conceivable that most of the reservation lands are of poor quality.

Location and distribution

Totalling 240,634 hectares, the reservations are scattered over 281,154 plots encircling 1,000 odd tribal clans in the hilly and mountainous regions, intermingled with the other two categories of national forest land. Table 1 shows the distribution of the aboriginal reservations by altitude.

Table 1. Distribution of Aboriginal Reservation Land by Altitude

Elevation (M above sea level)	Plot		Area		Average plot size (ha/plot)
	Number	%	Ha	%	
Below 200	70,201	24.80	27,983	11.63	0.40
200—400	59,476	21.00	47,197	19.61	0.80
400—600	54,691	19.31	49,438	20.54	0.90
600—900	54,894	19.39	56,045	23.29	1.02
900—1,200	27,450	9.69	34,713	14.43	1.26
1,200—1,600	11,414	4.03	18,658	7.75	1.63
1,600—2,000	4,124	1.46	5,535	2.30	1.34
Above 2,000	110	0.04	206	0.09	1.88
Undetermined	794	0.28	859	0.36	1.08
Total	283,154	100.00	240,634	100.00	

It can be seen from the table above that over three-fourths of the reserved land is located below 900 m in elevation. The average plot-size increases markedly at increasing altitude, its being less than 0.4 ha/plot in areas below 200 m up to 1.88 ha/plot in places above 2,000 m, indicating that the people as well as cropland are concentrated at the foot-hills and fringe areas.

Land-capability classification

A land-use inventory was made by the Taiwan Land Bureau along with the cadastral survey during 1960-67. All the lands of the aboriginal reservations were grouped into eight classes according to a modified version of the USDA land-capability classification system as shown in Table 2. Arable and marginal arable land, which totalled 46,444 ha, constituting only 19.3% of the whole reservation, represents the total area of farm land to be allotted to the aborigines. Table 3 indicates that over three-fourths of this cultivable land has an incline exceeding 3% and requiring erosion-control measures in one way or other; and that more than one-half of such lands is located on steep to very steep slopes, for which only bench-terraces provided with drainage structures can ensure continuous cultivation.

Table 2. Capability Classification of Reservation Land

Land-capability class		Area (ha)	%
Arable land	I	0	0
	II	22	0.01
	III	3,048	1.27
	IV	24,779	10.29
Marginal arable land	V	18,595	7.73
Sub-marginal land	VI	78,284	32.52
	VII	102,103	42.44
Non-agricultural land	VIII	11,998	4.99
Built-on land		1,805	0.75
Total		240,634	100.00

Table 3. Distribution of Cultivable Land by Slope

	Slope (in %)						
	0—3	3—8	8—15	15—25	25—45	45—55	Above 55%
Ha	11,416	1,881	2,861	5,058	16,427	7,714	1,087
%	24.58	4.05	6.16	10.89	35.37	16.61	2.34

Present land-use

According to the TLB land-use survey, two-thirds of the reservation land has already been occupied by private individuals and government organizations, and the remaining one-third has not been claimed by any users at all. Major land-use or cover types as of 1966 are summarized in Table 4.

Table 4. Land-Use Conditions of Aboriginal Reservations in 1966

	Used (occupied or claimed)					Unused (unoccupied)		
	Cultivated	Forest	Grasses	Others	Total	Forest	Idle	Total
Ha	71,793	86,113	848	1,807	160,561	75,682	4,391	80,073
%	29.83	35.79	0.35	0.75	66.72	31.45	1.83	33.28

A comparison between land-capability and the present land-use maps indicates that 47.4% of the cultivated land, or 34,013 ha, were classified as not suitable for cultivation. On the other hand, there are 7,631 ha which were mapped as cultivable but not being farmed yet. The total area available for farming is thus estimated at about 45,000 ha. With a population of some 155,000 (140,000 in aboriginal regions and 15,000 in lowland areas), the per-capita area of farmland would be less than 0.3 ha as against the permissible allotment of 0.4-0.8 ha approved by the Government.

What makes the situation worse is that out of the 160,561 ha of the "used" reservation land, about 18,000 ha are now being used by non-aborigines, including 10,000 ha encroached upon by lowlanders and 8,000 ha appropriated to government offices in the aboriginal regions. It is estimated that, at least, one-fourth of such lands belongs to the category of arable or marginal arable land. So, the actual allotment of farm land may average only about 0.25 ha per person. Betterment of the aborigines' living standard would, therefore, depend primarily on the development of improved pasture and tree crops on classes VI and VII lands.

Of the 71,793 ha of the existing cultivated land, 5,128 ha are made up of paddies and 66,665 ha of upland. The former occur mostly on narrow strips along streams and tributaries or small alluvial fans and are divided into 48,900 plots, averaging 0.125 ha/plot, while the latter is found all over the hillsides totalling 110,700 plots, at an average plot-size of 0.6 ha.

With respect to the cropping pattern, annual crops occupy 76.44% of the total cultivated area with sweet potato as the leading crop (20.89%), corn and rice next (14.31% and 13.47%, respectively), followed by millet (8.30%) and cassava (6.89%). The remaining 23.56% was devoted to perennials, mostly fruit crops. Per-unit yields amount to only about one-half to 60% of the average on the Island. Fallowing is still commonly practiced in the aboriginal reservations, involving no less than one-fourth of the cultivated area during most of the year. The cropping index for the whole reservation is estimated to be around 1.2. This low cropping intensity may be attributed chiefly to low soil fertility and high transportation cost for chemical fertilizers to the mountain areas.

MECHNAICAL RENEWAL OF TEA PLANTATIONS IN TAIWAN

Tien-Song Peng

How to raise the unit yield of Taiwan's tea plantations and produce more quality tea for export constitutes one of the important problems to be tackled by the agricultural agencies concerned. According to a PDAF survey, the average per hectare yield of 550 kg of crude tea is definitely too low when compared with that of either Japan or India.

A PDAF survey also revealed that about one-third of the tea plantations throughout this island are old and degenerated with the tea bushes planted half a century ago. Consequently, immediate regeneration of these plantations preferably through mechanical means is called for to boost tea production in the coming years.

In 1964 the first 35-bhp crawler tractor with an angle dozer, a plow and a harrow attached was imported by JCRR for trial use at the Taiwan Tea Experiment Station. In the ensuing trials the tractor and its attachments gave very satisfactory performance in both deep plowing and ground harrowing, which greatly facilitate the work of tea planting.

With a view to saving labor in the back-breaking job of digging up old tea bushes, the Taiwan TES developed a bush-uprooting machine which can do the work very neatly and efficiently. In order to demonstrate the newly developed method on tea plantations where old tea bushes had to be dug up and replaced with promising varieties, this Division assisted the Taiwan TES in conducting demonstrations with a 35-bhp crawler tractor with attachments since 1967. The work procedure, cost analysis and yield of tea leaves after demonstration may be briefly stated as follows:

Work procedure

Experimental plots totalled 75 ha of old, degenerated tea plantations located on the plains and tableland in the three northern prefectures of Taipei, Taoyuan and Hsinchu. Tea farmers in each demonstration area provided all the labor required to dig up the old tea bushes with bush-uprooting machines which were loaned to them free of charge by the Taiwan TES. As soon as the digging of tea bushes was completed, the land was plowed to a depth of 30-35 cm and then harrowed by a crawler tractor operated and maintained by Taiwan TES technicians.

As a means of improving soil fertility, green manure crops were planted immediately after the work of land preparation had been done by the cooperating farmers themselves. For the replanting, young tea bushes valued at NT$0.25 each were provided by the local governments and township offices involved. Tea seedlings to be propagated in the respective townships were multiplied by the layering method in order to maintain the characters of promising varieties.

For each hectare of the prepared land, a total of 14,000 tea bushes were replanted using only healthy seedlings with good root system free from diseases and insects. To facilitate mechanized cultural practices in the future, each row was set at 1.5m×0.5m. Manure provided by the farmers was applied before replanting at the rate of 14,000 kg per ha, whereas chemical fertilizers were applied to the experimental plots immediately after replanting. Other improved cultural practices were followed under the supervision of Taiwan TES technicians.

Cost analysis

1) Working capacity and annual use: 1.6 ha/day or 0.2 ha/hr and 500 hr/yr.
2) Overhead cost:

$$\text{Depreciation (D)} = \frac{\text{NT\$280,000(first cost)} + \text{NT\$28,000 (salvage value)}}{\text{10 (service year)}}$$

$$= \text{NT\$25,200/yr.}$$

$$\text{Interest (I)} = \frac{\text{NT\$280,000} + \text{NT\$28,000}}{2} \times 0.09 = \text{NT\$13,860/yr.}$$

$$\text{Overhead} = \frac{\text{NT\$25,200} + \text{NT\$13,860}}{0.2 \times 500} = \text{NT\$390.60/ha.}$$

3) Operation cost per hectare:
   Fuel: NT$16×12.5 gal/ha=NT$200
   Oil: NT$53×0.4 gal/ha=NT$21.20
   Maintenance and repair: NT$280,000×0,034/(0.2×500)=NT$95.20
   Labor: NT$150/1.6=NT$93.70
   Total operation expenses for 1 ha=NT$200+NT$21.20+NT$95.20 +NT$93.70=NT$410.10
   Total cost per hectare=NT$390.60+NT$410.10=NT$800.70

Yield of tea leaves after replanting

Year	Methods of renewal	Variety	Yield (kg/ha)		
			1st year	2nd year	3rd year
1967	Mechanical method	Chinhsin-Tapon	1,176	3,294	3,411
	Conventional method	—do—	—	500	833
1968	Mechanical method	Tainan No. 121	1,333	6,833	—
	Conventional method	Chinhsin-Tapon	—	—	—
1969	Mechanical method	Chinhsin-Tapon	1,756	—	—
	Conventional method	—do—	—	—	—

Summary

Under the JCRR-supported project, a total of 75 ha of old, degenerated tea plantations was renewed by mechanical means since 1967. To perform the work a 35-bhp crawler tractor with its attachments reaching a plowing depth of 30-35 cm and a plowing capacity of about 0.2 ha/hr, was used throughout the operation.

As indicated in the cost analysis, the total cost for mechanical renewal of each hectare of tea plantation was only some NT$ 800, which was well within the means of the local tea farmers. When compared with the average yield of tea in plantations renewed by the conventional method, the yield of tea leaves from the mechanically renewed plantations was significantly higher due to deeper plowing and better land preparation for the replanting of tea bushes. Now the demand for mechanical renewal of old, degenerated tea plantations is rising steadily as tea growers are attracted by the benefit of using modern devices for greater returns on their investments. However, further assistance from the government is still required to complete the program of mechanical renewal of tea plantations throughout the island.

INVESTIGATION OF BURROWING NEMATODE IN TAIWAN

T. T. Lo

Introduction

Nematodes or eelworms are tiny worms, round. elongated and smooth in shape, ranging from 300 to 1,000μ in length and 15 to 35μ in diameter. Certain species cause root knot disease of crop roots. The female worms become pear shaped at maturity.

Most of the nematodes inhabit the soil, either parasitic on the plant roots or free living. Distribution of nematodes is wide-spread; however, different species are always restricted to different levels unless they undergo the process of transmission caused by soil movement, farm equipment, irrigation or drainage water, animal feet, farm products, nursery plants, etc.

Among the parasitic species of nematodes, the burrowing nematode has long been recognized as the most destructive. The scientific name of the burrowing nematode has been changed several times in the past, such as *Tylenchus similis* before 1932, *Anguillutina similis* in 1932, *Rotylenchus similis* in 1936 and *Radopholus similis* since 1949.

Morphologically, the species is distinguished from the others by bigger lip of the male and stronger stylet and double ovaries of the female. The mode of attack upon crop roots is another characteristic of the burrowing nematode. The affected roots are bored with holes until eventually the whole plant dies off.

According to reports, the host range of the burrowing nematode is very wide, as over 280 varieties of dry land crops including such economic crops as citrus, bananas, carrot, tomato, ginger, sugarcane, etc., are subject to its attack. Therefore, every possible means to prevent the invasion of burrowing nematode has been adopted by those countries which are not yet infected.

In December 1969, the Ministry of Economic Affairs of the Republic of China received information from the Economic Councillor of the Chinese Embassy to Japan that the quarantine restriction on Japan's importation of root vegetables from Taiwan was due to our past record of burrowing nematode occurrence. Whether it did occur in Taiwan still remains a question, because the only basis for the reports came from Dr. Miyake, the Japanese plant pathologist of the Taiwan Sugar Experiment Station in pre-war days, who had only limited experience in nematology. According to the Chinese nematologists, no burrowing nematode has so far been found in Taiwan. In order to clarify this issue, a meeting was called by the Plant Industry Division, JCRR, on January 8, 1970 attended by all the nematologists in Taiwan and resulting in working out a joint research project briefly described below.

Methods of investigation and preliminary results

Since the burrowing nematode has a rather large host range, samples of soils were collected from the fields of the host crops from different regions for inspection and identification of the nematode in the laboratories at the Academia Sinica, the Bureau of Commodity Inspection and Quarantine, Taiwan Sugar Experiment Station, NCHU, Tainan FCES, Shihlin HES and Kaohsiung DAIS. Nematode specimens are now kept in a permanent file at Academia Sinica. A technical committee composed of nine nematologists has been organized to coordinate all the activities, and to hold meetings every two or three months.

Since the initiation of this project, all the nematologists and technicians participating in the studies under this project have been working cooperatively and conscientiously. Soil samples were periodically taken from 280 different localities by the nematologists and the technicians of six District Agricultural Improvement Stations. Then the nematode species were carefully identified by nine nematologists from various institutions. Up to the present, around 1,500 soil samples have been investigated and no burrowing nematode is found. The preliminary results of investigations are shown in Tables 1 and 2.

Evaluation of the results

The program of this investigation will be continued for two successive years, and altogether about 10,000 samples will be studied.

If nematode species, *Radopholus similis*, is found, its control will be immediately devised. On the other hand, the Japanese Government will be asked to rescind its quarantine regulation banning import of Taiwan's root vegetables, in an effort to balance the trade between the two countries and also solve our problem of surplus vegetables disposal in the winter season.

Table 1. Distribution of Parasitic Nematodes in Taiwan

Genus	Taipei	Hsinchu	Taichung	Tainan	Kaohsiung	Taitung	Hualien
1. *Aphelenchoides*	×	×	×	×	×	×	
2. *Aphelenchus*	×	×	×		×		
3. *Criconemoides*	×	×	×		×		
4. *Ditylenchus*		×		×		×	
5. *Dolichodorus*		×					
6. *Entylenchus*		×					
7. *Helicotylenchus*	×	×	×	×	×	×	
8. *Hemicriconemoides*	×		×		×		
9. *Hemicycliophora*	×	×			×		
10. *Hirschmaniella*	×	×	×	×	×	×	
11. *Hoplolaimus*	×				×		
12. *Laimpaphelenchus*				×			
13. *Longidorus*		×					
14. *Megadorus*		×					
15. *Meloidogyne*	×	×	×	×	×	×	
16. *Nacobbus*			×				
17. *Paratylenchus*	×	×	×	×		×	
18. *Pratylenchoides*		×					
19. *Pratylenchus*	×	×	×	×	×	×	
20. *Psilonchus*		×					
21. *Psendhalenchus*		×					
22. *Rotylenchoides*		×		×			
23. *Rotylenchulus*	×			×	×	×	
24. *Rotylenchus*		×					
25. *Trichodorus*	×	×		×			
26. *Trophotylenchulus*		×					
27. *Tylenchorhynchus*		×	×	×	×		
28. *Tylenchulus*	×	×	×	×	×	×	
29. *Tylenchus*	×	×		×	×		
30. *Xiphinema*						×	

Table 2. Districts Where Crops With Around 500 or more Parasitic Nematodes have been Inspected

District	Genus	No. of nematodes in 100 gm of soil or 10 gm of roots	Crops	
Taipei	*Tylenchulus*	784	Citrus	(S)
Hsinchu	*Hemicycliophora*	648	Tea	(R)
	Tylenchulus	3985	Citrus	(S)
Taichung	*Paratylenchus*	448	Tea	(S)
Tainan	*Tylenchulus*	603	Citrus	(S)
	〃	621	〃	(R)
Pingtung	*Meloidogyne*	1311	Tomato	(R)
	〃	892	〃	(R)
	〃	573	〃	(R)
	Pratylenchus	534	Banana	(R)
	〃	472	Citrus	(R)
	〃	1157	〃	(R)
	〃	795	〃	(R)
	Tylenchulus	3760	〃	(S)
	〃	2315	〃	(R)
	〃	1321	〃	(S)
	〃	2471	〃	(R)
	〃	5951	〃	(S)
	〃	4251	〃	(S)
	〃	1495	〃	(R)
	〃	3731	〃	(S)
	〃	2455	〃	(R)
	〃	2735	〃	(S)
	〃	745	〃	(R)
	〃	2401	〃	(S)
	〃	1173	〃	(R)
	〃	2311	〃	(S)
	〃	545	〃	(S)
	〃	3445	〃	(S)
	〃	1150	〃	(S)
	〃	2451	〃	(R)
	〃	845	〃	(S)
Taitung	*Tylenchulus*	795	Citrus	(S)

THE APPLICATION OF LOW-VOLUME PESTICIDE SPRAY IN TAIWAN

W. H. Horng

Low-volume (LV) ground spray application of pesticides is an innovation in pest control designed for the treatment of a large land area at greatly reduced labor cost without adding extra charge to a motorized knapsack mistblower needed for the application. With this new method a volume of 150 liters or even less of concentrated pesticidal spray is applied per hectare within a spraying duration of three quarters of an hour. When the LV technique is followed in accordance with the directions, a better coverage of the spray of finer particle size produces similar or even better results in the control of pests when compared with the conventional high-volume (HV) spray application at 1,200 lit/ha generally practised by the local farmers. Besides practically no phyto-toxicity due to the LV spray has been observed.

The derivation of LV spray concept

A. Disadvantages of conventional spraying method:

Spray droplets emitted by all spraying methods must pass from the sprayer through the air to the plant surfaces. In the conventional hydraulic ground spray application, pesticides are usually diluted thousandfold with water, and the spray droplets are heavy enough to be propelled through the air to target surfaces. The main purpose of the HV spray application is to provide such heavy droplets that can well cover the land area under treatment and to avoid injury to the plant from pesticidal application. The major shortcomings of the conventional HV spray may be illustrated by a typical example of pesticidal application for cotton pest control reported by the Agrochemical Division of Ciba Ltd. When cotton was treated either with an inter-row tractor-mounted boom and nozzle sprayer or a knapsack sprayer, 40% of the spray failed to hit the target plant, 40% was sprayed to run-off, and the rest only partly covered. The coverage was one-sided as viewed under an ultra-violet light when the deposit of spray contained a fluorescent dye. It was unlikely that two-sided coverage could be achieved unless elaborate nozzle arrangements were used.

B. Droplet size and number of droplets:

Phyto-toxicity from pesticidal application is believed possible from the initial deposit of relatively coarse particles of the spray which, in turn, coalesce on plant surfaces and form an oily film of pesticide itself or of the chemical plus solvent after evaporation of the water, thus affecting the respiration of the plant or damaging part of the plant tissues which can not tolerate the large concentrations of pesticide. Pesticides containing heavy metals may inflict similar injury on plants when they are sprayed at high concentrations. In ground application, if the particle size of the spray is rendered as small as possible, such injury can be prevented. It follows that the per hectare spray volume could be greatly reduced, because the spray distribution and collection of finer droplets on the plant surfaces can be very much improved. Table 1. shows the comparison of theoretical distribution of spray applied by low- and high-volume applications:

Table 1. Calculated Number of Droplets from Hydraulic Spray of 150 and 1,200 liters/hectare#

Droplet diameter (micron)	Droplet volume (micromilliliter)	Calculated number of droplets (billion per hectare)
Spray volume at 150 *lit/ha*:		
50	0.04	4,130
60	0.06	2,390
70	0.10	1,550
80	0.15	1,000
100	0.29	520
120	0.49	310
150	0.98	153
200	2.33	65
Spray volume at 1,200 *lit/ha*:		
250	4.25	282
300	7.85	154
350	12.46	96
400	18.60	65
450	26.48	45
500	36.33	33
550	47.35	25
600	62.78	19

Assuming a uniform droplet size and no change in droplet volume due to water evaporation or droplet coalescence.

C. Spray efficiency:

In all the spraying methods, spray efficiency can be measured by the deposit per unit emission (DUE), i.e., the percentage of the spray which is actually found on the target surface after spraying. In absolutely still air of uniform temperature, a droplet falls vertically at a terminal velocity determined by its weight, size and viscosity of air. The droplet decreases in weight and size during the course of falling due to evaporation of water as in the case of hydraulic spraying. When a motorized mistblower is used, the blast of air introduces a horizontal component, and the distance travelled before the droplet reaches the ground can be calculated. A local air turbulence is created within the crop when it is employed in cropland. This is a useful additional dispersing factor that increases the DUE if the droplets are fine enough, and so more droplets of the right size can be collected on the target surface. As aforestated, two-sided deposit of the spray particles on crop leaves can be achieved when a good turbulence is within the crop plant. An important advantage lies in the fact that there is less difference between the deposits on the upwind and downwind surfaces of the plant than between the upper and lower surfaces of the leaves sprayed by the conventional method. This can be explained by the basic principle of directional dispersal of particles. When droplets of different sizes are emitted by a stream of air under pressure, an obstructing surface will deflect the air stream, and with it the fine droplets, but not the coarse ones which have enough momentum to carry them straight onward in spite of the air deflection. The fine droplets thus flow around and over with the local turbulence and are finally collected by both sides of small surfaces such as rice leaves and stems. The DUE for the spray distribution of finer droplets can be more than doubled when compared with that of coarse droplets by conventional spray application.

D. Feasibility of LV spray:

To accomplish LV spray application of pesticide at a fixed volume such as 150 lit/ha, the delivery rate of the spray from the mistblower and the walking speed of the operator carrying the machine during spraying must be so adjusted that he could complete the coverage at pre-determined timing. His spray paths must be properly spaced according to the most effective range of spray, angle of elevation of the nozzle and speed of the engine determined by previous experiments under known conditions of wind velocity. It is technically feasible for him to do so, if the necessary preparatory work has been thoroughly carried out. The LV spray technique is not actually as tedious as one may think, because once he is familiar with the method, it is equally easy for him to spray the coverage as he has been doing well with the coventional HV spray application.

E. Toxicity of pesticide and droplet characteristics:

The use of LV spray application of toxic pesticides has to take into consideration the safety of the operator. Chemicals of highly acute dermal toxicity cannot be applied by LV spray technique, because the time required for the fine droplets to fall on target surface and the drift distance as shown in the following table may constitute a possible hazard.

Table 2. Characteristics of Water Droplets#

Droplet diameter (micron)	Time to fall 10 ft from rest (second)	Drift in 3-mph wind while falling 10 ft (ft)
5	3,600	18,000
33	90	400
100	11	50
200	4	18.6
500	2	7

Based on a report by F.A. Brooks, Agr. Eng., June 1947.

Performance of LV spray application

Late 1968 JCRR introduced the new idea of LV spray application of pesticides to the technical personnel of PDAF and then assisted the Taichung DAIS in trying out the technique. Five insecticides and 3 fungicides were chosen in 1969 for experimentation on the control of rice stem borer (*Chilo Suppressalis*), green leaf-hoppers (*Nephotettix* spp.) and rice blast (*Piricularia oryzae*). Results of the experiments were promising. So, the project was extended in 1970 using 6 brands of insecticides and 3 brands of fungicides for the control of the same disease/insect pests of rice and 3 other brands of fungicides for the control of downy mildew (*Peronospora brassicae*) of cabbage. Four of the insecticides and 2 of the fungicides used for the control of rice pests were different from those used in 1969. The experimental work is now in progress. Reported herein are largely the experiences gained in the first year.

A. Working conditions:

There are many factors influencing the results of LV spray application. To determine each factor takes time to find out an optimum condition in relation to the variation of the other factors. Therefore, the working conditions for a satisfactory LV spray application resorted to the trial and error method. For the first-year a Kyoritsu motorized knapsack mistblower, model DM-9 with a fine nozzle was used. A series of trial spray applications using water tinted with colored ink was made to pre-determine suitable adjustments of the machine and performance of the operator, and then the technique of the application was verified in practice. Listed below are the working conditions which have been found satisfactory for our purpose:

Spray volume: 150 lit/ha
Output of the mistblower: 3.3 lit/min
Load of the blower: at full speed
Angle of elevation of the nozzle: 6 to 10 degrees upward
Effective range of the spray: 6.5 m
Walking speed of the operator: 33 to 37 m/min (about 0.6 m/second)
Walking direction of the operator: 90 degrees to the wind

Spraying direction: leeward (same as wind direction)
Wind velocity: 5 m/second

B. Droplet spectrum and spray coverage:

Droplet spectrum and spray coverage distribution are closely correlated. For a mistblower, the droplet diameter may be controlled by the size of the nozzle used, the flow rate of the spray and the load of the blower. It may be determined by applying colored spray over glossy sheets of paper placed in the open field one meter apart at various distances from the nozzle and in line at right angle to the walking direction of the operator. After all droplets settle down on the ground, the papers are collected and checked for droplet count and measurement under a binocular microscope with a micron scale ocular. The following table shows a droplet spectrum together with the coverage of an experimental spray application under the above-mentioned working conditions at the Taichung DAIS in 1969.

Table 3. Droplet Diameter and Coverage of Low-Volume Spray Collected on Glossy Paper 1/

Distance from spray nozzle (meter)	Spot diameter (micron)		Droplet diameter 2/ (micron)		No. of droplets per sq. cm.
	max.	min.	max.	min.	
1	275	50	69	15	99
2	425	50	94	15	444
3	400	50	88	15	455
4	350	50	79	15	405
5	300	25	71	l.t. 15 3/	405
6	200	25	53	l.t. 15	301
7	175	25	50	l.t. 15	212
8	200	25	53	l.t. 15	170
9	100	25	28	l.t. 15	112
10	100	25	28	l.t. 15	123

1/ Sprayed from a Kyoritsu DM-9 motorized knapsack mistblower at a flow rate of 3.3 lit/min of water tinted with colored ink and adjusted for a spray volume of 150 lit/ha.

2/ Calculated from spot diameters by a spread factor for each spot size, according to the Plant Research and Development Report No. 26 of the American Cyanamid Co. (1967) .

3/ Less than 15 microns. No spread factor is given in the above-mentioned report for spot size less than 50 microns.

C. Work rate:

The LV spray application with a volume of 150 lit/ha is rapid and labor-saving. Along an imaginary strip of field 1,538 meters long and 6.5 meters wide, or about the size of one hectare, the operator walking at a slow and steady pace of about 0.6 meter per second could treat one hectare in 45 minutes. The actual rate of work may be somewhat below the potential, depending on the shape of the field. If two men work cooperatively and alternately as operator and helper in the morning and afternoon as recommended for safety, they can complete the LV spraying of 10 hectares in an 8-hour day. However, this rate can never be attained by the conventional HV spraying generally practised by the local farmers, who usually treat only about one hectare per 8-hour day for a 2-man team.

Evaluation of LV spray application in control of pests

Tabulated below are the results of the LV spray experiments for chemical control of rice pests conducted by the Taichung DAIS in 1969.

Table 4. Low-Volume Spray Application of Pesticides for the Control of Rice Disease/Insect Pests

Pesticide	Dose (lit or kg/ha)	Spray volume (lit/ha)	No. of appli-cations	Damage found 1/ (%)	Phyto-toxicity	Remarks yield index 1/
Rice stem borer control:						
45% EPN EC	1.2	150	3	0.7; 0.6 2/	None	105
	1.2	300	3	0.3; 2.1	None	104
	1.2	1,200	3	0.8; 0.4	None	106
47% Parathion EC	1.2	150	3	0.8; 2.1	None	104
	1.2	300	3	1.4; 1.4	None	105
	1.2	1,200	3	0.8; 0.8	None	104
50% Sumithion EC	1.2	150	3	0.7; 1.8	None	104
	1.2	300	3	1.0; 1.4	None	106
	1.2	1,200	3	0.3; 1.0	None	106
Control	—	—	—	4.0; 4.6	—	100
Green leaf-hoppers control:						
50% CPMC WP	1.2	150	4	40 3/	None	104
	1.2	300	4	30	None	104
	1.2	1,200	4	36	None	101
50% Carbaryl WP	1.2	150	4	35	None	101
	1.2	300	4	33	None	101
	1.2	1,200	4	16	None	103
Control	—	—	—	215	—	100
Rice blast control:						
2% Kasumin WP	1.2	150	4	16; 4.6 4/	None	115
	1.2	300	4	13; 4.8	None	115
	1.2	1,200	4	12; 4.2	None	120
48% Kitazin EC	1.2	150	4	15; 5.8	None	122
	1.2	300	4	14; 5.1	None	118
	1.2	1,200	4	13; 3.8	None	119
3% Hg Rionon EC	1.2	150	4	5; 4.8	Slight	129
	1.2	300	4	6; 3.5	None	126
	1.2	1,200	4	4; 3.2	None	130
Control	—	—	—	18; 12	—	100

1/ Average of five replications.
2/ First figure for "dead heart" and the second for "white ear".
3/ Number of insects collected at 40 sweeps with a net.
4/ First figure for leaf blast and the second for neck blast.

USE OF ETHYLENE DIBROMIDE TANK-DIP METHOD FOR CONTROL OF ORIENTAL FRUITFLY INFESTATION IN PONKAN

Ho-Yuan Liu

The oriental fruitfly (*Dacus dorsalis* Hendel) was found in Taiwan as early as 1911, and had been known to occur throughout the Island, attacking more than 30 species of economic and wild fruits. Because of widespread infestation caused by this insect pest, most of the fresh fruits, except green bananas and pineapples, could not be exported to noninfested countries, such as Japan, where stringent plant quarantine measures are enforced. In order to promote the export of Taiwan's fresh fruits, the search for an effective means to eliminate fruitfly infestation in commodity fruits is a matter of great importance.

Through negotiations with the Ministry of Agriculture and Forestry of Japan in 1961, an agreement was reached whereby the Japanese Government would legally relax her existing fruitfly quarantine regulations to permit the import of fresh fruits, starting with Ponkan (*Citrus poonensis* Hort. ex Tanaka) from Taiwan, on the condition that effective fruitfly disinfection measures were to be established and practised here. Consequeutly, studies on disinfection techniques for the control of fruitfly was initiated in 1962 under a JCRR project, starting with the mass production of laboratory test fruitflies.

Methods and experiments

The rearing procedures used by the Fruit Fly Investigations, Entomology Research Division, USDA, in Honolulu, Hawaii, were adopted with some modifications. For larval diet carrot or sweet potato yeast medium consisting of fresh carrot or sweet potato 100 g, TSC yeast 1/ 4 g, concentrated HCl 0.4 ml, sodium benzoate 0.1 g, water 40-60 ml was used. Sugar cubes, protein hydrolyzate-MRT granules 2/ and water were supplied as diet of adult flies in the cages. Under laboratory conditions, the life cycle of fruitfly is 24-36 hours, 7-10 days, 9-12 days and 9-14 days for egg, larval, pupal and preoviposition stages, respectively. The scope of rearing was considerably expanded to make possible the collection of 55 ml eggs (approximately 10^6 eggs) per day.

Several methods have been found effective in checking fruitfly infestation in fruit among which the application of ethylene dibromide (EDB) dips to control eggs and larvae of the Mediterranean fruitfly in citrus used effectively by Cohen

1/ A product of Taiwan Sugar Corporation.
2/ A product of M.R. Thompson, Inc. Cranford, N.J.

and Nadel in Israel, was adopted.

The effect of EDB emulsion, using Newcol-220 as an emulsifier, on the skin of Ponkan was first checked, followed by tests on its ovicidal and larvicidal effects. During the off-season of Ponkan, Tonkan (*C. tankan* Hayata) was used as test fruit instead.

The test fruits were exposed to the caged fruitflies for natural infestation overnight. The fruits infected by the egg and larval stages of the fruitfly were dipped in various concentrations of EDB emulsion for 3 minutes at 25° or 44°C. Following treatment, the fruits were kept in appropriate wooden boxes for 4-5 days at room temperature and then their skins were peeled off for inspection to determine insect mortality.

Based upon the experimental results up to December 1962, the first trial shipment of EDB-treated fruits to Japan was made in March 1963 under a special permit issued by the Minister of Agriculture and Forestry, Japan.

In order to incorporate the EDB tank-dip procedure into that of the existing commercial wax-coating of oranges, a 3,600-litre pilot dipping-tank was constructed for testing larger quantities of fruit as well as its mechanical efficiency. The quantity of fruit and test insects employed in the studies are summarized in Table 1.

Table 1. Population of Test Insects for a 3-minute Dip in EDB Emulsion

Experiment	Date	No. of tests	No. of infested fruit used	Estimated population of test insects	
				Eggs	Larvae
Laboratory tests	10/7-12/4/62	13	1,448 (Ponkan)	—	19,052
	4/10-7/3/63	8	1,629 (Tonkan)	478,134	46,574
	9/22-12/13/63	7	1,882 (Ponkan)	635,306	124,278
Pilot dipping-tank tests		4	1,049 (Ponkan) (5,576.4 kg)*	171,076	110,645
Total:			6,008	1,284,516	300,549

*Total number of Ponkan passing through the tank during tests.

Results

1) Mortality:

The results of experiments on 3-minute dips in various concentrations of EDB emulsion are summarized in Table 2. The EDB concentrations of 0.6 ml/l at 25° and 0.4 ml/l at 44°C gave complete kill of eggs and larval populations tested without any injury to the skin of Ponkan. Marginal concentrations of EDB to induce skin injury were 1.4 ml/l at 25° and 1.0 ml/l at 44°C, respectively. For practical commercial scale treatment, an adequate higher concentration of EDB should be considered to ensure quarantine security.

Table 2. Effectiveness of 3-minute EDB Dips at 25° and 44°C for Control of Fruitfly Infestation in Ponkan

Temperature of EDB emulsion (°C)	Effectiveness	
	Conc. of EDB (ml/l)	Mortality (%)
25	0.5	99.68-99.89
	0.6	100
44	0.3	99.06-99.89
	0.4	100

2) Loss of EDB in tank dips:

During the dip procedure, EDB is gradually lost from tank emulsion. A preliminary test showed that the rate of loss of EDB from the pilot tank during the treatment of 950 kg of fruit for 30 minutes was about 0.04 ml/l. Replenishment of this loss to keep the concentration of tank emulsion constant, should be done in commercial-scale treatment. In 1970, one of the two dipping tanks was equipped with a device to make possible continuous flow of concentrated EDB emulsion into the tank to maintain its EDB concentration at 1.10±0.05 ml/l to treat 51 m.t. of Ponkan in $12^1/_2$ hours.

3) First trial shipment of EDB-treated fruits to Japan:

A total of 1,140 fruits was shipped by a banana boat from Kaohsiung to Yokohama on March 11, 1963. The hold was ventilated at a rate of 8 m/sec and its temperature was from 25° down to 9°C on the voyage. Through two inspections at one-week interval, no chemical injury on the test fruits was detected, thus the procedure adopted was confirmed as effective.

4) EDB residues:

To determine the residual EDB in the treated Ponkan, random samplings were made from the commodity fruits during the 1969/70 exports for gas-liquid chromatographic analyses. Most of the residual EDB was lost after 3 days (Table 3).

Conclusion

Due to the effectiveness of this EDB tank-dip method, the Japanese government has amended her plant quarantine regulations to permit the import of Taiwan Ponkan since November, 1969, so 350 m.t. and 700 m.t. of Ponkan were exported to Japan in 1969 and 1970, respectively. No oriental fruitfly infested Ponkan has ever been detected in the shipments since the adoption of this method.

Table 3. Residues in Ponkans after EDB-dipping for 3 Minutes [a/]

Sampling date	Dosage (mg/l)	Ppm at indicated day post-treatment (as EDB)																			
		1				2				3				4				7[b/]			
		Wax coated		Non waxed		Wax coated		Non waxed		Wax coated		Non waxed		Wax coated		Non waxed		Wax coated		Non waxed	
		Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh	Peel	Flesh
12/2/69	2.75	5.0	—[c/]	3.6	—	1.9	—	2.0	—	0.9	—	0.8	—	0.4	—	0.3	—	—	—	—	—
12/9/69	2.75	0.4	—	0.8	—	0.2	—	0.2	—	0.1	—	0.2	—	Trace	—	Trace	—	—	—	—	—
12/13/69	2.78	1.7	—	1.0	—	0.2	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—
12/2/70	2.72	3.3[d/]		3.5		2.1		1.8													

a/ Based on Taiwan Hygienic Laboratory's GLC data.

b/ Stored at room temperature for 3 days and followed by 10°C for 4 days.

c/ Undetectable.

d/ Whole fruits.

INTEGRATED CONTROL OF VEGETABLE INSECTS

David F. Yen

Vegetable insect problems

High temperature and humidity greatly restrict vegetable production. On the other hand, such climatic conditions favor the rapid development and multiplication of insects.

So far, one hundred and thirty species of insects feeding on vegetables in Taiwan have been recorded, among which, a dozen species are of economic importance. In order to eliminate these pests, proper chemicals and their methods of application have been developed for use by growers. However, despite wide pesticide application and/or through indiscriminate use of chemicals, insects, especially lepidopterans such as the diamond-back moth, cabbage worm and cutworms, continue to thrive in vegetable gardens usually causing 5-15% loss per annum in terms of total production or monetary value, and reducing supply especially during the summer season.

Currently, about 20 kinds of synthetic organic chemicals have been recommended for use in the control of vegetable insects. Among them, 14 kinds of insecticides (Aldrin, DDVP, Dibrom, Malathion, Ambithion, Diazinon, Salithion, Cidial, Bayrusil, Cyanox, Actellic, Phosdep, Padan and Lannate) are used to combat lepidopterous pests. Unfortunately, none of these chemicals can provide a satisfactory solution to the insect problem; and conventional applications have many disadvantages, such as the development of insecticide-resistant strains, resurgence of treated populations, elevation of minor pests to a status of primary menace, pernicious effect on nontarget organisms, and general pollution of the environment with measurable residues of persistent chemicals.

Major vegetable insect pests and their natural enemies

Approximately there are 40 species or varieties of vegetables cultivated on this island. Cruciferous vegetables including Pai-chai, *Brassica chnensis*; cabbage, *Brassica capitata*; Chinese cabbage, *Brassica pekinensis*, and cauliflower, *Brassica oleracea*, are the most common varieties under intensive planting, constituting some 40% of the total vegetable production, according to a PDAF survey in 1970. An integrated control program to eliminate those insect pests attacking the leafy vegetables is called for through the introduction of their natural enemies. The major insect pests and their natural enemies are listed below:

Insect pest	Natural enemy
Order Lepidopter:	
Family Plutellidae:	
Plutella xylostella L. (diamond-back moth)	*Apanteles plutellae* Kurdj. *Diadromus collaruis* Grav. *Bacillus thuringiensis* Bern. Granulosis virus
Family Pieridae:	
Pieris rapae crucivora Boisd. (imported cabbage worm) *P. canidia sordida* Butler (cabbage worm)	*Pteromalus puparum* L. *Apanteles glomeratus* L. *Brachymeria euplaeae* Was. *Bacillus thuringiensis* Bern.
Family Noctuidae:	
Trichoplusia ni Hub. (cabbage looper)	*Apanteles ruficrus* Haledan *Copidosoma truneatellus* Dal. *Beauveria bassiana* Bals. *Bacillus thuringiensis* Bern. Polyhedrosis virus
Prodenia litura Fab. (Armyworm)	*Cantheconidea furcellate* Wolff. *Calleida splendidula* Fab. *Chaenius lynx* Chaudoir *Pheropsophus javanus* Dejean *Gonia cinerascens* Rondn. *Sarcophaga* sp. *Metopius kakogawanus* Mat. *Chelonus formosanus* Sonan *Apanteles ruficrus* Haledan *Beauveria bassiana* Bals. *Bacillus thuringiensis* Bern.
Agrotis ypsilon Rott. (cutworm)	*Bacillus thuringiensis* Bern.
Euxoa segetis Schiff. (cutworm)	*Bacillus thuringiensis* Bern.
Order Homoptera:	
Family Aphidae:	
Brevicoryne bassicae L. (cabbage aphid) *Lipaphis erysimi* Kal. (turnip aphid)	*Diaeretialla rapae* M'intosh *Ephedrus persicae* Erog. *Aphididius gifuensis* Ashm. *Ephedrus plagiator* Nees.
Myzus persicae Sulzer. (peach aphid)	*Lipolexis gracillis* Förster. *Coccinella septempunctata bruckii* Mui. *C. repanda* Thunberg. *C. octopunctata* Fab.

Insect pest	Natural enemy
	Lemnia swinhoei Crotch. *L. biplagiata* Swarts. *Menochilus sexmaculatus* Fab. *Propylaca japonica* Thunberg. *Scymnus* (*Pullus*) sp.
Order Coleoptera: Family Chrysomelidae: *Phyllotreta vittata* Fab. (striped flea beetle) *Phaedon brassicae* Baly (leaf beetle)	

Integrated control Program implemented in 1971

The use of natural enemies supported by appropriate insecticide applications will do a more thorough elimination job than that done by chemical sprays alone. For the purpose of checking the vegetable insect population as well as solving the toxicity and residue problems, an integrated control program combining non-chemical bio-agents and low toxic chemicals for the control of major vegetable insects has thus been designed and instituted in 1971.

Of the many species of bio-agents, the parasitic wasp, *Apanteles plutellae*, nematode DD-136, *Bacillus thuringiensis* and granulosis virus, which have been chosen from among 54 species of natural enemies of vegetable insects so far recorded on this island, are mass reared in the Laboratory of Entomology, NTU. Meanwhile, two more promising parasites, *Pteromalus puparum* and *Brachymeria obsculata* are collected, and placed under observation at the Beneficial Insect Laboratory, Department of Applied Zoology, TARI.

1. Sites for conducting the project:

A total of 100 hectares of vegetable gardens, 20 hectares each at Panchiao, Luchow, Shihlin, Chupei and Silo, were selected as sites for the implementation of this project.

2. Preliminary steps for carrying out the project:

   a) To rear the parasitic wasp, *Apanteles plutellae*, to 500,000-1,000,000 individuals.

   b) To rear DD-136 to about 100,000,000 nematodes.

   c) To design and construct parasite-release cages.

3. Field spray schedule:

Time of application	Treatment
a) 5 days after planting	35% Thiodan E.C.×1,500
b) 15 days after lst application	60% Diazinon E.C.×1,500
c) 10 days after 2nd application	Release parasite, *Apanteles plutellae* 100m²: (25+25) =2,500+2,500/ha
d) 7 days after parasite releasing, if insects occur in high density	50% DDVP E.C.×1,000
e) 7 days after DDVP application	Spray *Bacillus thuringiensis*+granulosis virus
f) 10 days after micropathogen application	Spray DD-136 nematode. 700 lit (1,400 nematodes/c.c.) /ha
g) Bio-agents may be repeatedly applied at intervals of 7 days up to harvest, if necessary	

In this integrated control program, the selection of vegetable varieties and the management of field practices and other cultural techniques were undertaken cooperately by PDAF and the various district agricultural improvement stations with the assistance of JCRR horticulturists. Besides, the above spray schedule for treating insect pests involving three chemicals (thiodan, diazinon and DDVP) and three bio-agents (parasitic wasp, parasitic nematodes and micropathogen) based on experiments and small-scale field trials has been proved successful in previous years. This program is now proceeding smoothly according to schedule. However, for the successful completion of an overall program of vegetable insect pests control, further studies on the ecology of pests and improvement of techniques should be continued.

THE NEWLY DEVELOPED COOPERATIVE SPRAYING SYSTEM IN CITRUS ORCHARDS

Yu-Tso Cheng

With more and more farm hands absorbed by industry and farm wages remaining high, the application of pesticides for the control of pests and diseases in citrus orchards, requiring no less than 15 times a year, faces a serious obstacle. The heavy outlay for labor and pesticides already takes up the lion's share of the cost of production. Moreover, most of the orchards in Taiwan average about one hectare in size and are widely scattered and fragmentary, so the spraying operations done individually can hardly attain uniformity and timeliness.

In order to increase the efficiency of pest control, JCRR, in cooperation with PDAF, launched in 1969 a pioneer project for cooperative spraying in citrus-producing areas by initiating a spraying system in a number of citrus orchards in order to cut down the cost of labor and make timely and systematic spraying of citrus trees in slopeland orchards possible.

At the outset, four locations of about 15 hectares each in the hilly areas of Hsinchu, Miaoli, Taichung and Chiayi were chosen as demonstration sites for the implementation of the project. At each location 15-20 families whose orchards were closely joined together were organized into a management committee composed of one representative from each family to take care of fund-raising, necessary constructions and maintenance of equipment, in addition to arranging spray schedules and keeping accounts for each family to share in the spraying expenses.

The basic installations on each site were a water pond, a mixing pond, a storage tank, a pump and motor and about 10,000 meters of pipe lines. The approximate cost for the installation of the entire system was around NT$100,000, of which one-third was subsidized by JCRR and the local government and the rest shared by the participating families.

At the highest slope on each site, a water pond capable of holding 1,000 liters of water either drawn from a mountain spring or from the ground by pumping was built first. At a location lower than the water pond, another pond of the same capacity was also built for mixing pesticides with water to obtain the desired concentrations. The diluted solution is released in part into a storage tank at a still lower level, ready for use. At the bottom of the tank a value connected with the main pipe line for conveying the well mixed pesticide solution to all parts of the demonstration orchards by gravity, or by pumping if higher pressure is required for spraying the areas higher up. The main pipe line is 16 mm in diameter and the branch line, 13 mm.

At the spot where the main pipeline branched off, a cement pillar was installed to fix the position of pipe connection with a faucet attached to control the flow of pesticide. Connecting the main line and the faucet are rubber tubes, and when a nozzle is attached, all the citrus trees within a radius of 50-100m could be sprayed in one operation.

The advantages of the cooperative spraying system may be summarized as follows:

1) Increase of control efficiency and labor saving:

For adequate control of pests and diseases in each citrus orchard with an average of 500 trees, about 2,000 liters of diluted pesticides per hectare are needed for each application. The following table shows the comparison between pesticide application with power sprayers and the cooperative spraying system:

Type of sprayers	No. of workmen per application	Volume of pesticides sprayed per day (liter)	No. of days required to complete one application	Total man days needed for one application
Semi-automatic sprayer	1	300	7	7
High pressure power sprayer	2	700	3	6
Cooperative spraying	3	4,000	1/2	1 1/2

As shown in the table above, approximately more than two-thirds of labor wages and 2 1/2-6 1/2 days from each application can be saved by cooperative spraying as compared with individual spraying.

2) Effective control of pests:

The cooperative spraying system greatly increased the effectiveness of pesticide sprays from high spraying pressure exerted by gravity and the even distribution of droplets on every part of the trees sprayed, thereby ensuring reliable, effective control of pests.

3) Pesticides mixed quickly and accurately:

As the water-holding capacity of the mixing pond is constant, it requires only a fixed amount of pesticides to be mixed with the same quantity of water to reach the desired concentrations. Furthermore, there is practically no waste of pesticides and hazard to workmen can be reduced to a minimum.

4) Control work made easy:

Difficulties are often encountered in individual applications, especially in lugging heavy equipment and chemical solutions up a slope. On the other hand cooperative application renders the task simple and easy by attaching a nozzle to the end of the rubber tube before releasing the mixed pesticide solution from the storage tank.

5) Dual function of the cooperative system:

During a dry spell the spraying system can easily and quickly be converted into a watering system to supply the water needed from the ponds to the orchards lying below.

The new system has been successfully demonstrated to the citrus growers at each location, besides holding field days and group gatherings to familiarize them with the spraying technique. Also held were training classes to show the growers how to use and maintain the equipment. It is gratifying to note that since the initiation of this system, the citrus growers in other parts of the island, who became aware of the advantages of such practice, have copied the design and the same installations for their own mutual benefit.

PROMOTION OF BEEKEEPING INDUSTRY IN TAIWAN

Jain-Min Tseng

The honeybee is not only valuable as a spreader of pollen necessary to seed and crop production, but it also produces honey, royal jelly and bee wax, particularly royal jelly which commands a very high price on the world market. Only recently has the importance of beekeeping been recognized by the local industry in improving the environment of fruit setting and raising the quality and quantity of royal jelly mainly for export. Due to the future potential of beekeeping, the farmers have shown their deep interest by developing it into a sizable business in a short time.

In 1969, the Taiwan Beekeepers Association (TBA) was organized and joined by 286 members with a total of 37,824 colonies of honeybee. Now the Association consists of 455 members with 61,845 colonies; and there are clear indications of further expansion of the industry. The promotional activities of the Association under the joint support of JCRR and PDAF are as follows:

1) Three apiary inspectors have been trained to inspect and supervise all the apiaries in Taiwan divided into three beekeeping areas for the convenience of inspection. A plan is afoot to launch an all-out "sweep" of the disease-ridden hives and to record the percentage of morbidity among the beehives in an effort to eradicate bee larval diseases. The inspectors will keep records of all the apiaries within his district, indicating where a beekeeper keeps his bees, how many colonies he maintains in each location and other pertinent details.

2) In order to destroy the infected brood-containing foundations, JCRR subsidized the beekeepers with 30,000 pieces of new wax foundations in 1970 and 200,000 more in 1971 to replace disease-infected honeycombs, which were burned locally. The new wax foundations were given free of charge to the beekeepers through the Taiwan Beekeepers' Association.

3) To disseminate technical know-how about the management of honeybees, especially the technique of controlling diseases, PDAF and TBA jointly conducted a number of field days and discussion meetings attended by the beekeepers in different areas under JCRR assistance.

4) Nectar plants and their distribution in Taiwan have been a subject of joint investigation by PDAF and TBA in 1969 and 1970. The results of the investigation are shown in the attached table.

5) Measures are being taken to prevent the infected colonies from being moved to other areas by convincing the beekeepers of the

foolishness of such practice.

6) Small apiaries of 5 colonies each have been set up at Hsinchu, Taichung, Tainan and Taitung DAISs, Chiayi farm of VACRS, Chiayi AES, Fengshan THES and the Taiwan Seed Service to serve as observation and demonstration stations for experiment an newly developed beekeeping techniques.

7) Work has already begun to add 130 more hectares of rapeseed planting in order to increase nectar sources during the winter season.

For further promotion of the beekeeping industry in the immediate future, an efficient system of marketing honeybee products will soon be established, while research on the control of honeybee pests, techniques to increase honey and royal jelly production, storage and transportation of honeybee products will be strengthened simultaneously.

A law will be drafted to guard against fraudulent practices of inferior honey production. Regulations will be promulgated to stipulate the timing of chemical sprays on agricultural crops, especially when the crops are in bloom. When interest in beekeeping has been aroused among farmers, it is only a matter of time for the beekeeping industry to flourish and join the rank of foreign exchange earners.

 Attachment

Kinds of Nectar Plants and Their Distribution in Taiwan

ha.

Nectar plant	Taipei	Tao-yuan	Hsin-chu	Miaoli	Tai-chung	Chang-hua	Nan-tou	Yunlin	Chiayi	Tainan	Kao-hsiung	Ping-tung	Tai-tung	Hualien	Total
Litchi	3	3	286	84	310	772	918	18	182	112	196	56	16	1	2,957
Longan	16	7	56	106	79	681	123	128	699	887	502	52	43	11	3,390
Wentan-pomelo	19	3	—	60	—	42	125	22	199	567	84	10	6	12	1,149
Tou-pomelo	21	4	—	63	50	5	26	—	21	21	—	5	4	9	229
Pai-pomelo	9	2	39	20	—	42	37	1	21	86	—	5	8	12	282
Ponkan	53	214	—	575	—	383	469	67	2,259	304	—	48	59	102	4,533
Tankan	5,984	211	—	811	—	10	54	6	20	—	—	—	293	594	7,983
Satsuma-orange	128	—	3,352	126	2,209	82	232	29	70	—	76	58	90	58	6,510
Valencia	30	11	—	29	—	143	241	303	1,153	—	157	28	865	—	2,960
Lemon	1	2	6	11	22	21	34	14	93	74	2	201	21	10	512
Wax apple	40	1	23	1	4	19	17	3	28	—	23	61	23	22	265
Loquat	2	5	55	177	126	175	64	10	15	—	3	—	23	7	662
Carambola	4	3	69	7	5	64	14	5	30	—	17	18	16	1	253
Jujube	—	—	—	—	—	—	—	9	—	—	76	—	—	—	85
Coco	1	—	—	—	—	—	—	—	—	—	—	1,604	—	—	1,605
Betel nut	—	—	—	5	37	36	63	21	747	18	23	227	245	87	1,509
Guava	727	45	268	147	61	398	42	32	137	—	136	141	89	50	2,273
Papaya	7	4	34	11	19	77	18	6	68	155	247	255	139	45	1,085
Muskmelon	—	—	17	—	869	34	9	—	645	—	—	190	1	—	1,765
Watermelon	47	225	46	1,124	—	226	—	4,404	1,733	—	—	705	30	19	8,559

Attachment (continued) Kinds of Nectar Plants and Their Distribution in Taiwan

ha.

Nectar plant	Taipei	Tao-yuan	Hsin-chu	Miaoli	Tai-chung	Chang-hua	Nan-tou	Yunlin	Chiayi	Tainan	Kao-hsiung	Ping-tung	Tai-tung	Hualien	Total
Oriental pickling-melon	47	268	—	144	—	288	60	—	232	—	—	109	25	113	1,286
Cucumber	191	120	—	62	—	147	203	—	27	—	—	553	44	70	1,417
Squash	72	148	88	109	175	57	13	—	20	—	—	108	109	36	965
Pineapple	8	—	22	43	544	3,221	2,660	507	648	1,551	—	1,389	3,141	1,027	14,761
Grape	17	15	96	93	180	203	51	34	45	—	1	1	16	7	759
Strawberry	—	—	—	20	—	—	—	—	—	—	—	—	—	—	20
Cassava	5	—	48	778	2,172	221	6,229	42	2,017	6,988	—	2,123	1,264	60	21,947
Sweet potato	—	7,083	2,461	11,339	9,168	24,877	9,349	24,618	30,794	35,671	—	14,374	8,907	13,246	191,887
Sorghum	—	18	68	173	737	—	—	112	—	320	—	17	7	70	1,522
Corn	—	81	505	256	899	1,219	713	1,851	2,784	4,285	—	550	5,353	—	18,496
Peanuts	1,193	549	1,473	4,794	3,193	6,358	1,497	37,156	10,273	3,505	—	1,306	4,144	—	75,441
Rapeseed	—	56	272	182	1,702	9,276	3	403	—	—	—	—	4	298	12,196
Radish	8,270	7,333	2,513	—	—	—	392	—	—	—	—	—	—	—	18,508
Sesame	—	—	9	10	—	84	37	132	825	3,284	—	24	12	136	4,553
Tea	11,454	7,083	9,813	3,693	—	—	2,209	—	—	—	—	2	71	137	34,462
Cotton	—	—	829	54	—	—	57	13	1,422	295	—	10	4	630	3,314
Pear	—	—	—	—	—	—	1,287	—	—	—	—	—	—	—	1,287
Sesbania	—	—	—	—	585	423	—	244	—	—	—	2,615	1,198	109	5,174
Astragalus	1,993	6,503	3,307	1,956	—	1,115	—	—	—	—	—	—	—	443	15,317