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THINKING AND PRACTICE TOWARD BETTER CROP PRODUCTION

— PID Activities —

(July 1969—June 1970)

TAIPEI, TAIWAN, REPUBLIC OF CHINA
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JOINT COMMISSION ON RURAL RECONSTRUCTION

PREFACE

In FY1970 several big events took place in Taiwan agriculture. Among them the most important ones were: (1) the promulgation of a new agricultural policy by the Government for the further strengthening of food production, agricultural research, farm mechanization, marketing and agricultural financing, and for the development of marginal and slope lands; (2) the severe damage to land and crops by Typhoons, Elsie and Flossie, which not only drastically cut down the overall agricultural production for that period but also greatly lowered land productivity immediately afterward; (3) a sharp decrease in planted acreage of dryland crops and winter crops due to rapid industrialization and urbanization: and (4) the tragic death of Mr. Y. K. King, JCRR Secretary-General, in a car accident in June 1970.

High labor cost in the rural areas has significantly affected both cropping patterns and crop production. It is natural that farmers should choose to grow crops of high economic value in order to earn more. On the other hand, the reduction of fertilizer prices as a government attempt to lower the cost of production has also had considerable impact on crop production.

Under the changing conditions of agriculture, it is evident that our specialists are facing many challenges in their own fields. For instance, research on the chemical residue problem, selection of proper crops for slopeland farming, stepped-up farm mechanization, profitable crop production, improvement of post-harvest handling techniques, effective pest control and economical use of fertilizers all pose problems to be dealt with in coping with the changing agricultural pattern. Some of the reports in this publication show how JCRR proposes to meet the new challenges; more research efforts are required in the years to come.

Chief
Plant Industry Division
Joint Commission on
Rural Reconstruction

July 1, 1970

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THE POSSIBILITY AND PROBLEMS ENCOUNTERED IN USING HYBRID VIGOR OF RICE

Cheng-Hwa Huang

Introduction

The use of hybrid vigor in crop improvement has interested breeders for many years. The most significant achievement of using hybrid vigor in crop production is the development of hybrid corn. During the period from 1936 to 1945, the planting acreage under hybrid corn in the corn belt of the United States was expanded from 5% to 90% and the yield also increased by about 20%. Through continuous efforts made by plant breeders in various countries, many hybrid crops of economic importance such as onion, tomato, cucumber and several other horticultural crops have also been successfully developed in the past twenty years.

Rice is an autogamous crop, so the utilization of hybrid vigor should take into account such problems as hybrid sterility, the degree of hybrid vigor and the method of mass production of hybrid seeds. So far little research work has been done to evaluate the hybrid vigor of rice. Several rice research workers reported the finding of considerable heterosis in grain yield in different cross combinations of rice (Ramaih, 1941; Harada, 1953; Subliah, 1961; Richharia, 1962; Madhasudhana, 1965), but without conclusive data.

In 1965, Peter R. Jennings of the International Rice Research Institute reported the observation of an unusually high level of hybrid vigor involving earliness, total tiller number and percent productive tillers, and grain yield among 24 *indica* × *japonica* hybrids of rice. However, the carefully programmed experiments involving two hybrids of B5711A1 × Tainan 3 and Chianung 242 × BPI-76 grown under spacing of 25 cm × 25 cm at three nitrogen levels did not show any superiority in grain yield. It was explained that the extremely vigorous vegetative development of the hybrid during the early growth stages resulted in excessive mutual shading which inhibited net assimilation and reduced the amount of storage products available for translocation to the grain during the period from flowering to maturity. Based on this conclusion, Dr. Jennings considered heterosis of rice for yield to be difficult to demonstrate under the low light, high temperature conditions of the tropics.

In order to re-appraise the existence or non-existence of hybrid vigor in terms of grain yield under the environmental conditions here as well as to explore a new concept for rice improvement in the future, a research program entitled "Studies on the hybrid vigor of rice and its practical utilization" has been conducted since 1967 at the Chiayi AES and TARI at the initiation of JCRR. The purpose of this research program consists of three parts: the investigation and screening of levels of hybrid vigor among different cross combinations in F_1 and F_2 generations, the determination of the effect of cultural practices on the expression of hybrid vigor and establishing a method of mass production of hybrid seeds. The preliminary results obtained by the said institutions in the past three years are summarized in this report.

Recently, it was reported that the development of hybrid wheat with the help of male sterile lines would be commercialized very soon in the United States. Because rice is also a self-fertilized plant, it seems that the use of male sterile line may be the right solution to mass production of hybrid seeds. But, the mechanism of flowering of rice which is slightly different from that of wheat could limit the effect of using male sterile line for mass production of hybrid seeds. Furthermore, the transfer of male sterility to a desirable rice variety through repeated backcrossings is also a delicate time-consuming technique. Therefore, an attempt has been made to study the possibility of utilizing the F_2 or even F_3 for economical production of hybrid seeds in addition to the use of male sterile lines. Of course, the degree of reduced hybrid vigor and the segregation tendency in F_2 or F_3 population should be taken into consideration.

Screening Test of Hybrid Vigor Among F_1 Crosses

A large number of crosses involving *japonica* and *indica* rice varieties were made at the Chiayi AES and TARI in the past three years. The results of screening tests in terms of grain yield of these F_1s can be summarized as follows:

Station	Crop* season	No. of crosses	Hybrid vigor (av. yield in %)**		
			Over MP	Over HP	Over CK
TARI	1968-I	90	25.9 (55)	18.2 (44)	14.7 (27)
	1969-I	50	40.0 (30)	33.3 (21)	34.8 (24)
	-II	39	50.2 (23)	26.1 (18)	23.6 (15)
Chiayi AES	1967-II	22	19.4 (15)	23.7 (7)	3.4 (11)
	1968-I	17	43.7 (8)	61.7 (4)	39.7 (10)
	-II	20	20.9 (8)	17.1 (3)	23.6 (3)
	1969-I A	27	9.2 (24)	8.3 (16)	16.0 (24)
	B	18	13.4 (13)	14.4 (10)	16.7 (16)
	C	15	28.0 (14)	18.4 (13)	16.2 (15)
	1969-II A	24	19.0 (16)	15.4 (12)	17.9 (16)
	B	28	17.2 (24)	13.2 (19)	17.0 (26)
	C	29	24.8 (22)	19.3 (20)	33.2 (21)

Note: * I and II indicate first and second rice crops, respectively. A, B, and C indicate the crossing of early-maturing varieties, late-maturing varieties and *indica* varieties, respectively.

** Figures in parentheses indicate the number of cros.ses The check varieties used by TARI are Taichung 65 (68-I) and Tainan 3 (69-I and 69-II), and those used by the Chiayi AES are Tainan 5 (67-II, 68-I, 68-II, 69-I B and 69-II B), Taichung 180 (69-I A and 69-II A) and Taichung Native 1 (69-I C and 69-II C).

Of the aforesaid F_1 crosses, a considerable number have shown rather high levels of hybrid vigor as compared with that of the high yielding parent (HP), or check varieties (CK). The parents of these crosses and their actual yields are listed as follows:

Station	Crop season	Crosses	Yield (kg/ha)	Comparison (%)	
				To HP	To CK
TARI	1968-I	Tainung Line 3×Yoshino 1	4,102	31.0	22.9
		Tainung 38×Kwangfu 401	4,402	37.5	31.9
		Tainung 60×Kwangfu 401	4,075	59.8	22.1
		Kwangfu 401×Kaohsiung 135	4,165	41.8	24.8
		Aikoku×Taichung 186	4,120	31.3	23.4
		Tainung 60×Chianung 242	4,196	38.3	25.7
	1969-I	55-II-1×Chianan 8	3,200	23.6	47.7
		55-II-1×Hualien 18	3,500	25.0	61.6
		Taipei 177×Kwangfu 401	4,666	133.3	115.4
		Taichung 178×Taipei 309	4,857	102.4	124.2
	1969-II	Saturn×55-II-1	4,437	71.0	46.0
		Hualien 18×Tainan 3	4,326	44.0	42.0
		Hualien 18×Miaoli 20	4,217	38.0	38.0
		Taichung 187×Kaohsiung 53	4,402	50.0	44.0
		Aikawa×55-II-1	4,560	14.0	50.0
Chiayi* AES	1969-I	Tainan 5×Line 561111	50.6	46.2	(To MP)
		IR-8×Taichung Native 1	39.9	35.3	(〃)
		CP 231×Taichung Native 1	40.4	47.5	(〃)
		Taichung Native 1×CP 231	46.0	67.9	(〃)
	1969-II	IR-8×Ti-chueh-min-tang	41.7	35.0	(〃)
		IR-8×IR-9-60	37.4	38.0	(〃)
		Ti-chueh-min-tang×IR-9-60	42.4	55.3	(〃)
		IR-9-60×Saturn	26.7	54.3	(〃)

* The figure for yield is in grams per plant.

Reduction of Hybrid Vigor

The Chiayi AES has studied the degree of reduced hybrid vigor in the F_2 generation and the results are as follows:

Crosses	F_1			F_2		
	Yield (g/plant)	To MP %	To CK %	Yield (g/plant)	To MP %	To CK %
Taichung 180×Fukunishiki	30.5	23.4	24.1	33.6	6.3	5.7
Fukunishiki×Taichung 180	30.2	23.4	24.1	35.5	12.3	11.6
Line 56102×Tanikazu	26.7	13.7	7.7	30.5	0.7	−4.1
Tainan 5×Hsin-kin-nan-fon	29.0	29.6	2.6	28.5	0.9	−5.6
Taichung (N) 1×CP 231	37.2	81.8	76.5	30.3	16.6	−6.4

The preliminary results as presented in the above table indicated that though F_1 hybrid vigor decreased in the following generation, but the degree of reduction varied with different crosses. Therefore, the use of hybrid vigor in F_2 is possible if more screening tests could be made.

The Effect of Cultural Practices on the Performance of Hybrid Vigor

Several field experiments have been conducted at the Chiayi AES and TARI to evaluate the influence of cultural practices on the expression of hybrid vigor. The summarized results are as follows:

1. Hybrid vigor observed at the F_2 generation under different treatments of plant spacing, number of seedlings per hill and fertilization in comparison with MP in percentage (Chiayi AES):

Crop season	Spacing (cm)		Seedlings/hill		Fertilization	
	25×20	25×10	1	3	Light	Heavy
1968-I	−13.2	7.4	3.5	−6.3	—	—
-II	25.8	3.3	9.2	18.4	—	—
1969-I	4.6	5.1	4.9	5.0	3.7	6.1
-II	−6.2	−9.4	−5.2	−10.1	−6.9	−8.8

2. The grain yield variations of hybrids of rice under different plant spacings and fertilizer treatments (TARI):

Unit: kg/ha

Crosses	N—1		N—2	
	25×20	25×10	25×20	25×10
Taichung 65×Tainan 3	3,628	3,709	3,208	2,736
Kwangfu 401×Tainung 38	3,963	4,137	3,285	3,183
Tainan 3 (check)	3,960	3,591	3,342	2,610

The experimental results obtained at the Chiayi AES showed wide fluctuation and it is very difficult to demonstrate the effect of cultural practice on the performance of hybrid vigor. However, the results of TARI studies indicated that light fertilization either in dense or sparse plant spacing is more profitable in showing the hybrid vigor of rice.

Method of Mass Production of Hybrid Seeds

The use of male sterile line is, of course, an effective method for mass economical production of hybrid seeds of rice. The Rice Research Laboratory of TARI is now undertaking research work along this line. But, several problems as listed below should be solved before any promising male sterile line can be practically and profitably used:

1. The transfer of male sterility
2. The maintenance of male sterility
3. The introduction of fertility-restoring gene into genic and cytoplasmic male sterile lines

4. The out-crossing problem of male sterile line

Besides using the male sterile line to produce F_1 hybrid seeds, an attempt has also been made to use F_2 hybrids. According to preliminary investigation conducted at the Chiayi AES, if one single seedling of F_1 hybrid after transplanting is divided and re-transplanted at the tillering stage and the stubbles of these re-transplanted rice plants are again propagated by the vegetative method, each F_1 hybrid seed can produce about 635 grams of F_2 seeds. This means that by this method 100 F_1 hybrid seeds can produce more than 60 kilograms of F_2 seeds. The recommended seeding rate for one hectare under the transplanted condition in Taiwan is about 40-60 kilograms. Therefore, it is apparent that the use of F_2 hybrid vigor through the vegetative propagation of F_1 is not a delicate and time-consuming job. If a farmer has only one hectare of rice land, it is necessary for him to grow only 100 F_1 plants for seed production. Listed below are the results of Chiayi AES preliminary investigation:

Method of vegetative propagation	Early-maturing varieties	Late-maturing varieties	*indica* rice	Average
F_2 seeds obtained through division method from each F_1 seedling (g) – A	27.05	177.23	230.07	144.78
F_2 seeds obtained through division and cutting methods from each F_1 stubble (g) – B	73.49	818.50	577.92	489.97
A+B	100.54	995.73	807.99	624.75
F_2 seeds obtained directly through each F_1 seedling (g) – CK	14.25	25.20	27.50	22.32
Increased amount of F_2 seeds through vegetative propagation (g)	86.29	970.53	780.49	612.43
Percentage of increase	505.54	3,851.31	2,838.15	2,743.86

EVOLUTION OF RICE CULTURE IN TAIWAN

Chen-Seng Huang

Through exchanges of technical knowledge with rice workers and the dispatch of rice teams to foreign countries, Taiwan has in recent years won international repute for its intensive rice cultural techniques and success in varietal improvement. This has aroused the interest of some foreign visitors who frequently asked questions concerning the cultural techniques of rice and the origin of the high-yield *indica* rice varieties possessing semi-dwarf gene. In answer to these questions, the author reviewed available literature dealing with rice up to the 17th century. Reported here are the results of the review.

To familiarize the reader with the history of Taiwan, the article "Gesehichte der Insel Formosa" written by L. Riess (1897) is briefly summarized below:

605-1500	Small-scale immigration of Polynesians to Taiwan
1368-1600	Small-scale immigration of Hakka tribal people from the mainland
1542-1609	Formosa known to Europeans
1609-1625	Failure of Japanese invasion
1621	Beginning of large-scale Chinese immigrations
1624-1661	Occupation of the southern part of the island by Dutch sailors who later drove out the Spaniards occupying the northern part
1661-1683	Take-over of Taiwan by Koxinga
1683-1895	Rule by the Ching dynasty
1895-1945	Japanese occupation
1945-present	Restoration to the Republic of China

Rice Cultural Systems

The history of Taiwan rice cultural systems can be divided into four stages based on the methods of cultivation, i. e., the primitive Polynesian method, the Chinese method, the improved Chinese method and mechanization.

A. *The Polynesian method*

Apparently the method of growing rice was first introduced by the Polynesians during their immigration. C.E.S. stated the following in his "Verwaarloode Formosa" in 1675 (translated from the Chinese version):

> "The major occupation of the Polynesians is farming, especially that of growing rice. Despite the vast acreage of land at their disposal, they grow only enough food to meet their own consumption, sometimes not even enough. Women have to do all the farm work. They harvest

the ripened rice and store it in their dwellings; then shatter and hand-mill just enough everyday for daily use. Hand-milling is again the women's job. The women hang a couple of rice bundles over the fire to dry at night and hand-mill them two hours before daylight for one day's use."

Rev. Campbell reported in his book "Formosa under Dutch" (1903) as follows:

> "The women, who are complete drudges, do most of the farm work, and since neither horses, cows, nor ploughs are used, all work has to be slowly done by means of pickaxes. Moreover, whenever rice appears above ground, much labour is needed for the process of transplanting, as the young shoots stand very thick in some places and not in others. Again, when rice becomes ripe, they do not use sickles to cut it down or scythes to move it, but have a certain kind of instrument in the form of a knife, with which they cut off each stalk separately at about a hand-breadth from the ear."

It is clear that the early Polynesians in Taiwan sowed rice seed in holes dug with pickaxes without land preparation and harvested the rice panicles one by one instead of cutting the whole plant. This primitive way of growing rice is the traditional method practised by the present Polynesian people in tropical Asia.

B. The Chinese method

The Chinese who immigrated to Taiwan in the early days were probably not engaged immediately in agriculture, but when large-scale immigration took place, some settlers reclaimed land in order to farm and build villages, thus introducing their way of growing rice into Taiwan. Past Chinese records dealing with rice culture in Taiwan in the early Ching dynasty are briefly as follows:

Taiwan Fu-Chih, first edition; Volume 7, Topography; Section on Chinese Customs (1694): "Only one crop is harvested a year from most of the paddy fields on the fertile plain, yet it supplies enough staple food for consumption except in a year of bad harvest."

Chu-Lo-Hsien-Chi, Volume 12 (1717): "On the mainland (Fukien) growing two crops a year is possible because of relatively warm weather and well distributed rainfall in three seasons. The first crop is generally harvested in June (lunar calendar) and the second one is planted in autumn. This place (Chiayi Hsien, Taiwan), despite much warmer weather, produces only a single crop of rice a year due to dry spring season."

Shiao-Hai Chen made a report on rice culture in Taiwan in his book of travel during the early Ching dynasty, translated below: "In Ho-pau-su of the central district (Chiayi Hsien), temporary dams and reservoirs are constructed to store spring and river water to grow two rice crops a year. Quite a few farmers grow two rice crops a year after the construction of many dams and reservoirs. In Hsia-tam-suei of the southern district, early rice is sown in October, transplanted in November and harvested the following March or April (all according to lunar calendar), thus ensuring two rice crops a year."

Tai-Hai-Tsai-Lu; Volume 3, Chyh-kan-pi-tan; Section on Products (1736): "The soil in three hsiens with different topography is generally fertile. Only the late rice crop is grown in Tainan Hsien, while the early crop is planted in the paddy fields close to the water source in the Tam-suei area of Fengshan Hsien. However, only the late crop yields a bumper harvest. . . . The Hakka people living in Tsao-chou, located in the southern part of Tam-suei, constructed reservoirs to irrigate their land. . . . The soil is so fertile that no animal urine nor dung is needed. Panicles would become heavy and the plant overgrows if fertilization were applied. But yield much higher than that on the mainland can be attained in every 'mu' of land without much labor after transplanting. Later some farmers would enrich the soil with animal urine and dung in the Tainan area on account of reduced soil fertility caused by erosion and sand accumulation."

Taiwan Fu-Chih, third edition; Volume 4, Taxation (1), Land Tax (1771-1779): "With enough land to reclaim, the farmers commonly abandon the fields that have been cultivated for three years in succession on account of reduced soil fertility."

As Fig. 1 illustrates, two planting seasons of rice in Chu-Lo Hsien (Chiayi) in the 18th century were from February to April and June according to lunar calendar, respectively. Apparently the varieties for spring planting was upland rice with seeding possibly done after spring rain, while summer planting in lowland started at the beginning of tropical monsoon.

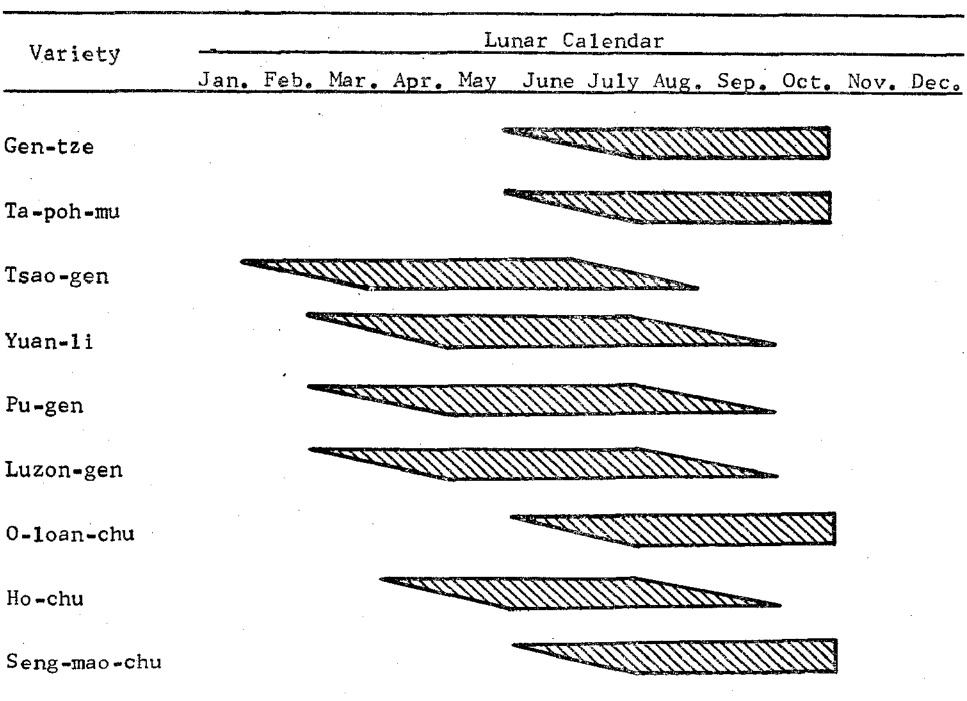

Fig. 1. Rice growing seasons in Chiayi Hsien in the early 18th century (from Chu-Lo-Hsien-Chih, 1717)

Dr. G. L. Mackay (1895) described in detail the Chinese method of rice culture in the late Ching dynasty as below:

"The seeds are first steeped in water and spread out in large baskets under cover till they have begun to sprout. They are then sown thickly in a small bed, which is protected from winds and birds and watered with a liquid fertilizer. At the expiration of three months, the crop is about six inches high and is ready for transplanting.

"Meanwhile the large rice-field has been plowed, harrowed and prepared for the plants. The field slopes down to one side, and the plots already referred to are submerged in about three inches of water. The water from the reservoirs or aqueduct is first run into the plot farthest up the slope, from which it is let into the others, one by one, by opening a place in the dividing mounds or dikes. The entire field must be kept under water from before transplanting until the grain is ready to harvest.

"Transplanting rice is a very arduous and wearisome task. The farmer digs up the plants from the bed in spadefuls, leaving a liberal supply of mould about the roots. With a large flat basket of these seedling plants he goes into the field, where the mud and water reach his knees. The basket floats on the water. Carrying a supply of the plants in his left hand, the farmer wades backward from end to end of the row, and breaking off tufts, he sinks them in the soft mud beneath the water at intervals of about eighteen inches. The rows are about two feet apart. Then a fortnight later he goes over the whole field again on his bare knees, removing the duck weed and other obnoxious growths. .... Before the grain is ripe he may possibly go through the field once more, bending the bunches down to protect them from sweeping wind.

"Three months after the transplanting comes the harvest. This is a busy season with the husbandman. The water is drained off; the rice is cut rapidly by a reaper with the sickle or bill-hook, and made into bunches large enough to be held conveniently between the hands. The reaper is followed immediately by a thresher, who draws after him a portable tub. This tub has poles set up around almost the entire mouth, to which is fastened a canvas screen to prevent the rice grains from flying away. At the open space the thresher stands, and taking a bunch of rice, he gives it two smart strokes on a ladder-like framework placed within the tub after the fashion of a wash-board. The grain is carried home in large baskets and placed on a winnowing-floor in front of the house. There it is cared for, heaped up, and covered every night with rice-straw, and spread out in the morning with wooden hoes. It is then winnowed in a fanning-mill similar to that used by the Western farmers, and is stowed away in granaries. ....

"The sheaves are no sooner removed from the field than the plowman is once more in the mud and water, a second crop, which is now ready for transplanting, is immediately 'set', and the second harvest is reaped in September or October. After second crop is removed, some plant sweet-potatoes, others mustard or rape for fertilizing. Three crops are thus secured in the course of a year."

Surprisingly enough, the rice cultural system in present Taiwan does not differ too much from that practised in the late Ching dynasty. At present, one can see similar ways of growing rice in some other Asian countries. Whether this system originated from China mainland or other countries is beyond the scope of this review. The Chinese settlers in Taiwan in the 19th century apparently employed the following principles of rice culture.

a) The fundamental principles of farming, irrigation and drainage.

b) General land preparation by using animal power, plows and harrows.

c) Establishment of seedbed nursery and transplanting of seedlings at a certain spacing, though not in the check-row fashion.

d) Hand-weeding.

e) Use of animal dung and urine or green manure to fertilize the soil.

f) Harvesting the whole plant of rice and threshing it with a thresher.

g) Storing of dried clean rice grain.

Table 1 shows the grain yields throughout the island by the Chinese method during 1901-03, as estimated by the Agricultural Experiment Station, Taipei, in 1906, in comparison with the highest yield attained during the Japanese era and that after World War II by the improved Chinese method.

Table 1. Total acreage and production of rice in Taiwan in 1901-03 in comparison with the yield records during Japanese era and after World War II

Year	Production in brown rice (MT)	Acreage (ha)	Average yield of brown rice (MT/ha)	Remarks
1901	490,334[1)]	353,365[2)]	1.388	
1902	451,427[1)]	344,992[2)]	1.309	
1903	588,353[1)]	394,872[2)]	1.490	
1938	1,402,414	625,398	2.242	Highest during Japanese era
1968	2,518,103	789,906	3.188	Highest after World War II

1) Converted from rough rice at the rate of 0.8.
2) Converted from "chia" at the rate of 0.9699.

C. *Improved Chinese method*

This is the traditional Chinese method of growing rice modified according to the experimental results that increased rice yield or saved labor. When the Japanese took over the island, they began to establish a number of experiment stations to improve agriculture in Taiwan. Undoubtedly the Japanese contributed a lot in the past towards improving rice culture on the island. However, real progress was made only after restoration of Taiwan due to the efforts of the Chinese agricultural workers. As a matter of fact, the improved Chinese method is the backbone of rice cultural techniques introduced by various Chinese rice demonstration teams or by the rice technical missions to foreign countries. The major modifications in the traditional method are listed below:

a) The use of improved plows to facilitate deep-plowing or of garden-tractor to save labor.

b) The use of certified seed of improved varieties.

c) Employment of improved elevated seedbeds or protected beds and reduction in time for raising seedlings in nurseries.

d) Adoption of check-row spacing or wide-row close-spacing planting methods.

e) Application of chemical fertilizers to enrich the soil.

f) Application of insecticides and fungicides to control pests.

g) The use of herbicides or rotary weeders to control weeds.

h) The use of rotary threshers or engine-driven threshers.

The most fruitful result was obtained by the delivery of this improved Chinese method as a package of knowledge in the so-called integrated demonstration or extension projects. Nevertheless, this intensive system of rice culture is subject to criticism for it is too labor-consuming to be practical on large farms or where there is a shortage of man-labor. The difficulties met by some of the Chinese rice teams abroad and the bottlenecks caused by rapid industrilization on the island strongly support this criticism.

D. Mechanization

In order to solve the above-mentioned difficulties, Taiwan has gradually entered into the mechanization stage of rice culture. The rice cultural system in the United States serves as an apt example for rice mechanization on large farms, but it is not suitable for small farms. Farm machinery adaptable for use on such small rice farms in Taiwan was developed and used in Japan. Generally speaking, the improved Chinese method of rice culture requires four labor-consuming processes, land preparation by animal power, transplanting by hand, hand-weeding and team harvesting. Land preparation is now being mechanized by the use of rotary tillers, while hand-weeding is being replaced by the application of herbicides. The technical problems in mechanizing the two processes have been primarily solved, but greater efforts are still needed to make them acceptable to the majority of farmers in Taiwan.

As for planting, two possibilities of mechanization at the present time are the use of direct-seeders and hand-driven transplanters. Unfortunately, no experiment in Taiwan has been done to demonstrate that direct-seeding of rice on dryland, or in lines on wet land, outyields or is on par with transplanted rice, despite the fact that the highest yield of 10,341 kg/ha ever obtained at IRRI occurred in a direct-seeded field of IR-8 by broadcasting in mud (IRRI Annual Report, 1967). Moreover, the multiple-cropping system will not allow direct-seeding practice to be included in its intensive rotation. This system, if it remains unchanged, will be eliminated sooner or later due to continuous increase of labor cost, thus yielding more way for direct-seeding of rice. In the meantime, the transplanter experiments and demonstrations initiated by JCRR and conducted by the various rice stations in the past revealed that mechanical problems of the transplanter and raising seedlings in wooden-boxes were major bottlenecks. The large farm owners, who should be the first ones to accept mechanization, will be discouraged by the necessity of raising seedlings in more than 100 boxes for planting one hectare of rice. Thus, some of the technical problems in mechanizing rice planting in Taiwan still remain unsolved. The experience gained from the introduction of the Japanese rice combine in 1969 by the Provincial Food Bureau is valuable in tracing the bottlenecks that have to be overcome before adopting this machine for general use in Taiwan. To be tackled are the various technical problems, among which the growing of short and not-easily-shattered varieties should receive utmost attention.

Rice Varieties

The rice varieties grown in Taiwan today differ considerably from those in the past. The early Polynesian immigrants naturally used the varieties they brought in, while the Chinese immigrants introduced various Chinese varieties from the mainland. The Japanese who occupied Taiwan for 50 years concentrated their breeding efforts mostly in developing Ponlai varieties without paying much attention to the improvement of the Chinese *indica* rice. Prior to the Restoration of Taiwan, the *indica* varieties possessing semi-dwarf gene had never been used in the breeding programs.

A. Polynesian varieties

Unfortunately, the auther could not find any record dealing with the names of rice varieties introduced by the early Polynesians. The only information available is the 68 mountain rice varieties that were collected in the Japanese era and preserved at the Taiwan Agricultural Research Institute, Taipei. Among them, 21 varieties have waxy endosperm; 3 are reselected; 4 unknown and 21 photoperiod-sensitive. These varieties, with their names in the language of the mountain people, are generally tall and leafy with big panicles. The Polynesians selected the vigorous and big-panicle varieties to suit their way of rice culture, that is, dibbling seed without weeding and harvesting panicle by panicle. Apparently the semi-dwarf types which were lodge resistant and favorably responsive to nitrogen fertilizers could not survive under such rigid natural and artificial selection.

B. Chinese varieties

There are a few official records dealing with rice varieties grown in the Ching Dynasty in Taiwan, among them the history book, Taiwan Fan-Chih, is probably the most representative. Translated below is a part of Chapter 10 of Chulo[1] Hsien-Chih, Volume 6, Taiwan Fan-Chih (1717):

1) Present Chiayi Hsien, where large-scale Chinese immigration started.

"Among the Keng[1] rice varieties, there is the Gen rice which according to Hsiang-Shan-Yeh-Lu[2] was introduced from the Gen[3] city of Fukien on account of its drought resistance, by the imperial envoy sent by Emperor Chen-Chung of the Sung dynasty. This was later introduced into Kiangsu, Anhui and Chekiang provinces in the years of Hsiang-hu[4] of the same dynasty. It was probably much earlier than this when this variety got into China. Two types of the Gen rice are the white rice which is easily hand-milled and the red rice. The Gen rice is generally sown in June or July and harvested in October. The late-maturing variety, Ko-san-hsian, grown mainly by the aborigines, has large grains, about double the size of the ordinary ones and is aromatic when cooked. The Chinese pay several times the price of ordinary rice to buy it. Ta-poh-mu, a kind of white rice, is suitable for cultivation in lowland where drainage is poor. The height of the plant is determined by the depth of water in the field. It is sown and harvested almost at the same time as the Gen rice. Tsao-gen, an upland variety, has red otherwise white rice which is generally small and poor in quality. It is planted in February or March and havested in July or August. Yuan-li, whose grain is white and soft,[5] produces less steamed rice after cooking than the other varieties. This variety with short grain is generally sown on dryland in March or April and harvested in August or September. Pu-gen, a red rice variety, is also grown in the same period. The people in Taiwan did not like it at first, although its price does not differ too much from that of the other varieties now, because it is used for making wine. Luzon-gen has small slender grain, white or red, and is grown in the same manner as Pu-gen."

In addition to the above-mentioned varieties, a brief description of several waxy varieties, such as 0-loan-chu, Ho-chu, Gen-chu, Hu-pi-chu and Seng-mao-chu, was also given in the said Chapter.

Translated below is another representative document on rice varieties contained in the chapter of Tamsui-Ting-Chih, Volume 1, Taiwan Fan-Chih (1871):

"Pu-gen, which is characterized by white glume, red, thick seed coat, is planted on dryland in March or April and harvested in August or September. According to Chih-kan-pi-tan,[6] the Keng rice varieties grown in paddy field are Tsao-gen and Uan-gen, all white in color: while those grown on dryland is called Pu-gen, characterized by red

1) Meaning non-waxy.
2) A book written in the Sung dynasty.
3) In present Indochina; or called Champa; Gen is pronounced Chiam in Fukien dialects.
4) Name of an era.
5) Equivalent to "sticky".
6) In Tai-Hai-Tsai-Lu, 1736.
Note: All the months given in the quotations are lunar

rice. The variety Hua-lo, distinguishable by mottled big grain, includes two grain types, big and small. Chin-yu-tsa is also of two grain types. Yin-yu-tsau or Chih-hsih-jih-tsau is planted early spring maturing in about 70 days. Kiong-hou, red otherwise white, is characterized by long grain. Wan-keng-hsien is an all-season variety; while Yuan-li, grown in the same way as Pu-gen, has white soft rice producing less steamed rice after cooking.... San-pei looks like Gen rice. According to Taiwan Chih-Lueh, there are three kinds of rice. One is Chan-ku, the seedcoat of which is thick and the grain can be stored for a relatively long period of time. It is grown mainly in the Tainan, Fengshan and Chiayi areas. The second is Pu-ku, an upland rice, which is chiefly grown in Fengshan. The third is San-pei, characterized by big grain with thin seedcoat, but spoils easily during storage. This variety including the early and late maturing types is grown in Changhua and Pei-lu or in the northern district. Other Keng rice varieties are Hong-geo-tsau, a "red-legged" white rice; Ta-poh-mu having white, big grain adaptable to lowland culture, because the plant height depends upon the depth of water in the field; Tang-san-tsau, originated from China mainland; Shuang-chiang, matured on or about August 14; Men-tze, red-awned about 15-18 cm long and saline resistant; Koh-san-hsian, grown in Taoyuan, having big grain and savory smell."

Within various Ting- or Hsien-Chih, which the author reviewed, no variety was found to have the name beginning with "Dee-geo", or "I-geo" or "Hsia-geo" meaning "short-legged". This may suggest that the semi-dwarf type was not a major commercial variety during 1870's, otherwise it would be recorded in the books. On the other hand, some varieties like Hua-lo and Chin-yu-tsau apparently were differentiated into small and big grain types. As mentioned in the following paragraphs, differentiation within variety was found quite common when the Japanese made the first survey on Taiwan native rice varieties.

According to the Japanese-operated Agricultural Experiment Station in Taipei, a survey made on rice varieties from 1902 to 1905 led to the general recognition of 379 commercial varieties, excluding upland varieties, in Taiwan. Hua-lo, Woo-koh, Chin-yu, Woo-gen, Liu-chou, Ta-hua, Tsu-hsi-chu and O-loan-chu were the major varieties in the first crop; and Keh-tze, Woo-tao, Pai-koh, Nan-tsai-sen and Wan-hua were included in the second crop. Most of these varieties were well differentiated, for example, the Hua-lo variety group had Kao-geo-hua-lo (tall), Hsia-geo-hua-lo (low-legged), Ying-wei-hua-lo (hard-tipped), Woo-koh-hua-lo (black hulled), Chih-ku-hua-lo (red stemmed), Pai-koh-hua-lo (white hulled), Hua-lo-chu (waxy), I-geo-hua-lo (short legged), Woo-geo-yu-li-hua-lo (black-legged with small-grain), etc. Almost the same differentiation was also noted in the Ta-hua, Woo-koh and Liu-chou variety groups. Moreover, many of the variety groups had both short and tall types. I-geo-woo-gen, a synonym of Dee-geo-woo-gen, recorded by the Taiwan Agricultural Experiment Station in 1906 can be considered as the first indication of the existence of semi-dwarf varieties of *indica* rice which have been intensively used in the rice breeding programs in the tropics and sub-tropics. The place of production was Hsinchu Ting (Hsinchu Hsien) where, according to "The Handbook of Taiwan Farmers" (1944), 1,000 to 5,000 hectares of paddy field were planted to Dee-geo-woo-gen, not I-geo-woo-gen, in the first crop of 1939. Lin *et al* (1967) of the Provincial Department of Agriculture and Forestry reported that 10,907 hectares were planted to Dee-geo-woo-gen in the island's first crop of 1953, but dropped to 4,168 hectares in the first crop of 1965.

After World War II, the Taiwan Agricultural Research Institute introduced 660 rice varieties, belonging mainly to the *indica* group, from China mainland. Among them only 7 varieties have their names starting with "Dee-geo" or "I-geo" or "Hsia-geo" and only one photoperiod sensitive variety I-geo-ta-pai-koh (Accession number 1478) of the 7 varieties is shorter than 100 cm. By treating several tall representative native varieties with radiation, Li *et al* (1961) succeeded in inducing short mutants, which looked similar to Taichung Native 1 or other dwarf *indica* in plant type as well as in yield potential.

The differentiation of grain size within Hua-lo and Chin-yu-tsau as described in Tamsui Ting-Chih suggested that the semi-dwarf gene possibly existed in 1870's, since grain length was frequently reported to correlate with plant height. This genotype, whatever its origin, could easily get into other varieties including Woo-gen through natural cross-fertilization to add short type to many of the variety groups investigated by the Japanese. Dee-geo-woo-gen or I-geo-gen was thus selected by enterprising farmers for cultivation sometime before 1902 and possibly after 1870. Meanwhile the mutation origin of the dwarf gene is supported not only by the experimental results obtained by Li *et al* but also by the general concept of evolution genetics that mutants constitute the principal raw materials for the differentiation of living things. However, no record was found to indicate or imply that mutation occurred on China mainland or in Taiwan. Apparently the Chinese method of rice culture had played an important role in keeping the dwarf mutation in rice population from the undergoing rapid selection due to its poor competitive ability against the tall original plants.

C. *Ponlai rice*

The Japanese started varietal improvement of rice in Taiwan in 1915 by purifying the Taiwan native varieties, and probably it was the only improvement made on Taiwan *indica* rice by the Japanese. Breeding work on *japonica* rice was started in 1921 and the variety released in 1922 was Nakamura (in Japanese) or Chung-tsung (in Chinese). This variety plus other *japonica* varieties released later were thus named "Ponlai", a commercial term given by Governor Isawa in 1926. Since Nakamura was the first Ponlai variety, many farmers in central and southern Taiwan still call it Chung-tsung instead of Ponlai at present. Up to World War II, Japanese breeders developed various Ponlai varieties, including the famous Taichung 65 and Chianan 8. Chianan 8, because of its poor looking quality, did not receive much attention from the Japanese breeders, despite its high-yield capacity. It was released after World War II and became the top-leading variety in 1959-68. After the War, Chinese breeders developed more famous Ponlai varieties like Hsinchu 56, Chianung 242, Taichung 186, Tainan No. 3 and 5, Kaohsiung 56, etc. Among them the most successful one is Tainan 5, the top-leading variety since 1967 and to which 199,436 hectares were planted in 1968. Huang *et al* (1961) computed the coefficients of relationship between each of the 96 Ponlai varieties and Taichung 65 as well as between each of the 96 and *indica* varieties. As a result, these Ponlai varieties were found to be related to Taichung 65, except 17 varieties developed earlier. The peak of coefficient distribution was between 25% to 45%. On the other hand, 65 out of 96 varieties were found related to *indica* and the average of their coefficients was about 20%. However, none of these Ponlai varieties were related to the semi-dwarf *indica* varieties.

As shown in Table 2, the acreage of the Ponlai varieties hit the peak in 1944, the last year of Japanese occupation, but dropped suddenly, about 40 per cent, the following year. Then it continued to climb to an all-time high in 1968.

Table 2. Changes in acreage of Ponlai and Tsailai varieties in Taiwan (excluding upland and waxy varieties)

Year	Ponlai (A)	Tsailai (B)	Percentage (A)/(B)	Year	Ponlai (A)	Tsailai (B)	Percentage (A)/(B)
	(ha)	(ha)	(%)		(ha)	(ha)	(%)
1901	0	294,507	0	1944	400,855	181,350	221.04
1921	0	408,104	0	1945	263,968	224,637	117.51
1922	414	414,003	0.1	1953	395,966	317,852	124.58
1931	143,013	339,631	42.11	1961	486,444	259,452	187.49
1938	301,376	247,459	121.77	1968	562,430	192,133	292.72

Note: From Lin *et al*, PDAF, 1967.

Irrespective of their defects, such as less blast-disease resistance, relatively lower tillering ability and tall stature prone to lodging, especially under high nitrogen, the Ponlai varieties gained acreage mainly because of their good cooking quality favored by the Japanese. Other superior characteristics of the Ponlai varieties are: adaptability to sub-tropical climate, slow leaf senescence and higher response to nitrogen than the tall *indica* in terms of grain yield.

D. Dwarf "indica" varieties

After World War II, the Taiwan Agricultural Research Institute (TARI) started the breeding program of *indica* varieties, financially supported by the Joint Commission on Rural Reconstruction (JCRR). A few years later, the program was abandoned due to increasing demands for Ponlai rice in the Japanese market. In 1949, a rice breeder of the Taichung District Agricultural

Improvement Station made a cross between Tsai-yuan-thong and Dee-geo-woo-gen from which Taichung Native 1 was selected in 1952. The word "Native", though a misnomer, remains unchanged due to its popularity. For other *indica* varieties developed later, "Sen", an equivalent of *indica*, has been used instead of "Native". Taichung Native 1 has become the conceptual variety of the high-yield *indica*, because it broke down the Japanese concept that the *indica* varieties had lower nitrogen response than the *japonica* in terms of grain yield. Following Taichung Native 1, released were Taichung Sen 2, Kaohsiung Sen Nos. 1 and 2, and Hsin-tsu-I-geo-gen from pure line selections. Taichung Native 1, Taichung Sen 2 and I-geo-gen occupied 77.6 per cent of the total *indica* rice area in the first crop and 45.2 per cent in the second crop of 1968. Taichung Native 1 is grown mainly in central and southern Taiwan, Taichung Sen 2 in central Taiwan, while I-geo-gen in the north.

The next topic which may be of interest to rice workers is the difference in the yield capacity between the high-yield Ponlai varieties and the high-yield dwarf *indica* varieties. Fortunately most of the field experiments associated with cultural methods involved both variety types. Summarized below are the results of the various JCRR-supported experiments conducted in different areas of Taiwan:

a) In northern Taiwan:

The data shown in Table 3 were obtained by the Taipei DAIS from yield trials of Taipei 309 and I-geo-gen transplanted from March 13 at 10-day intervals to August 13 at two sites in 1967. I-geo-gen was on a par with or having a higher yield capacity than Taipei 309, if it was not transplanted on or after August 5 and before March 13 at both testing sites. The low yield of I-geo-gen transplanted in August was probably caused by the low temperature in the later growth stage.

Table 3. Average yield of Taipei 309 and I-geo-gen at Ping-lin and Mu-san in 1967 (kg/ha)

Date of transplanting	Ping-lin		Mu-san	
	Taipei 309	I-geo-gen	Taipei 309	I-geo-gen
D1, Mar. 13, 1967	7,430	7,320	5,800	5,910
D2, Mar. 23	7,150	8,009	5,890	6,010
D3, Apr. 2	6,540	6,980	4,860	5,130
——				
——				
D14, July 26	4,230	4,380	4,980	5,060
D15, Aug. 5	4,630	4,150	4,030	4,270
D16, Aug. 15	3,630	3,050	2,540	2,620

W. L. Huang *et al* (1966) tested five varieties under N-P-K fertilizer treatments at Lotung, Taoyuan and Changhwa, in 1965. As shown in Table 4, dwarf *indica* rice out-yielded the high-yield Ponlai rice.

Table 4. The overall average yields of five rice varieties under 8 fertilizer treatments at Lotung, Taoyuan and Changhwa in 1965 (ton/ha)

Crop season	Hsinchu 56	Taichung 65	Chianung 242	I-geo-gen	Taichung Native 1
I	4.12	3.95	4.23	4.72	4.40
II	4.50	4.65	4.67	4.91	4.87

Rice breeders in TARI obtained a yield of 4.87 tons per hectare from a newly tested Ponlai variety, Tainung Yuh 61; and 4.47 tons from I-geo-gen in a large-plot trial in the first crop of 1969. On the other hand, Liu-tou, I-geo-gen, Taipei 309 and Tainung Yuh 61 gave respective yields of 4.15, 4.06, 3.70 and 4.07 tons per hectare from two-replication plots in the same season.

b) In central Taiwan:

In the transplanter experiments conducted by the Taichung DAIS and the Chiayi Branch of the Tainan DAIS in 1968, the dwarf *indica* variety Taichung Sen 2, as shown in Table 5, exhibited higher yield capacity than the high-yield Ponlai varieties.

Table 5. Average yields of entries tested in transplanter experiments in Taichung and Chiayi in 1968 (kg/ha)

Site	Variety	1st crop	2nd crop
Taichung	Taichung Sen 2	6,089	5,520
	Tainan 3	4,950	5,180
	Chianung 242	4,620	5,280
Chiayi	Taichung Sen 2	6,266	2,811
	Chianung 242	6,126	2,499
	Tainan 3	5,572	2,831

In the direct-seeding experiments conducted by Taichung DAIS in the same year, Taichung Native 1 also out-yielded all the tested varieties, including Tainan 5, Chianung 242, Taichung Nos. 186 and 184 and several upland varieties. Among the varieties tested for their water-plant relationship at Taichung in 1967 and 1969, Taichung Sen 2 consistently out-yielded others including the high-yield Ponlai varieties.

c) In southern Taiwan:

The average yields of several varieties tested in the transplanter experiments at the Kaohsiung DAIS in 1968 are shown in Table 6. The grain yield of dwarf *indica* surpassed that of high-yield Ponlai, though not significantly. In the direct-seeding experiment conduted in the same year, the yield of Kaohsiung Sen Yuh 6 was the highest

Table 6. Average yields of the varieties tested in the transplanter experiments at Kaohsiung DAIS in 1968 (kg/ha)

Variety	1st crop	2nd crop	Variety	1st crop	2nd crop
Taichung (N) 1	5,700	—	Tainan 3	5,600	3,100
Taichung Sen 2	—	3,220	Chianung 242	5,560	2,780

in the first crop, while Kaohsiung Sen Yuh Nos. 10, 11 and 12 showed most promise in the second crop. Apparently the high-tillering dwarf *indicas* were superior to the Ponlai varieties in yield under the direct-seeding system. Among the 10 short varieties, including *indica* and *japonica*, Kaohsiung-Sen-Yuh 2 showed a tendency to yield higher than the Ponlai variety of Kaohsiung Yuh 369 in the first crop; however, this relationship was reversed in the second crop. In a year-round planting experiment, Kaohsiung 136 and Tainan 3 were higher in yield than both Taichung Native 1 and IR-8 when transplanted in season, while off-season plantings would give reverse results. Len *et al* (1968) reported that IR-8 had higher yield ability than Chianan 8, in the Pingtung area in the second crop, and that the leaf area index was responsible for this yield difference. The Kaohsiung DAIS conducted a top-yield experiment in 1969 and found that Kaohsiung-Sen-Yuh 11 was the highest yielder (Table 7).

Table 7. Top-yield experiment (1st crop, 1969)

Variety	High yielding field (kg/ha)	Low yielding field (kg/ha)	Remarks
Kaohsiung Yuh 52	7,660	6,280	New Ponlai
Kaohsiung Yuh 755	8,710	7,220	—ditto—
Kaohsiung Sen Yuh 11	10,040	8,080	New short *indica*
Kaohsiung Sen Yuh 12	8,920	7,010	—ditto—

The yield data presented in the previous paragraphs were obtained mainly from experiments dealing with cultural methods, therefore evidently more variety trials are needed to obtain more conclusive results. Moreover, different maturing dates of the different varieties may interact with temperature and solar energy during the 40 days after flowering to influence precision of yield comparison. However, so far the evidences strongly suggest that the yield ability of dwarf *indica* varieties would even surpass that of Ponlai in many cases. These dwarf *indica* varieties, due to their short stature, can stand erect on heavily fertilized soil without lodging, besides possessing high-tillering ability and superior light-receiving system of leaves and stems. In addition, the short stature would facilitate not only chemical spraying but also control against cold and combine harvesting.

Despite their high-yield capacity, the dwarf *indica* varieties have not received enough attention from the food-policy makers in Taiwan. As a matter of fact, the price of rice in Taiwan has been so regulated that 103 kg of *indica* rice are priced the same as 100 kg of Ponlai rice. The poor quality of *indica* rice mainly accounts for this discriminative measure. The present short *indica* varieties possess such defective characters as: (1) poor rice quality as indicated by the percentage of white belly and white core, the degree of endosperm transparence and cooking behavier; (2) less resistance to bacterial leaf-blight disease and blast disease (Taichung Sen 2); (3) less resistance against cold; (4) shattering habit that may cause a high loss of grain in combine harvesting; (5) quick leaf senescence and red leaves when temperature is low and the soil lacks nitrogen; (6) sensitivity to some pesticides; and (7) relatively lower recovery of brown rice and milled rice.

Even with these defects, the short *indica* rice varieties remarkably out-yielded the high-yield Ponlai varieties in many instances as mentioned before. If these unfavorable traits can be eliminated or improved through breeding techniques, there will be a bright future for increased rice production in Taiwan.

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BREEDING CROPS FOR RESISTANCE TO MAJOR DISEASES—THE MOST NEEDED PROGRAM IN TAIWAN

Chien-Pan Cheng

The use of resistant varieties has long proved to be the most economical and reliable way of controlling plant diseases throughout the world. In Taiwan, when strong emphasis is put on the use of chemicals in both research and field application for the control of plant diseases, the work of breeding disease-resistant varieties has to some extent been neglected. Chemical control is not only too costly (about NT$600,000,000 or US$15,000,000 was spent on fungicides and insecticides in Taiwan in 1968), but the residual effects through improper use also are hazardous. A reinforced, well-organized disease resistance breeding program on a long-term basis, therefore, merits special attention and prompt action of the agricultural workers in Taiwan.

Present Status and Problems Encountered in the Disease Resistance Breeding Program

1. The control of the following diseases of major field crops through developing resistant varieties is of economic importance:

Rice	—blast (*Piricularia oryzae*)
	—bacterial leaf blight (*Xanthomonas oryzae*)
Corn	—downy mildew (*Sclerospora sacchari*)
Peanut	—leaf spot (*Mycosphaerella berkeleyii*)
	(*M. arachidicolla*)
Soybean	—rust (*Phakopsora pachyrhizi*)
Sweet potato	—Witches' broom (mycoplasma)

2. The importance of disease resistance in the overall plant protection program has been slighted by most agricultural workers and also by the government agencies responsible for crop improvement. The false impression that the use of fungicide, whatever its cost, is the best way to control plant diseases still prevails among the majority of people.

3. There are indications that plant breeders often do not use or apply the findings of plant pathologists obtained in tackling the same disease problem. Likewise, the pathologists sometimes do not know the exact problems the plant breeders want them to solve. The progress of the disease resistance breeding program has thus been lagging behind for lack of communication and cooperation between plant breeders and plant pathologists.

4. Generally speaking, the work done in this field during the past years

in Taiwan has been fragmentary and inefficient. In the breeding area, most of the efforts have been directed toward varietal tests on the reactions to certain diseases and the routine screenings in a segregated population under natural conditions. While in the pathological area, the activities have dealt mostly with the isolation of pathogen, basic physiological tests on pathogen and race identification. (The classification of the races of *P. oryzae* still remains controversial.)

Guidance for the Proposal of a Reinforced Disease Resistance Breeding Program

1. Education on the importance and value of using the disease resistance crop varieties should be further extended among the local agricultural workers.

2. Plant disease is an expression of the result of the interaction between host and pathogen. The reaction of the host, either resistance or susceptibility to a certain pathogen, and the pathogenicity of the pathogen, either virulence or avirulence to a certain host, all originate genetically. The relationship between host and pathogen is, therefore, considered a complexity. It is strongly recommended that more pathological training be provided for the plant breeders and more genetic training for the plant pathologists, who are responsible for carrying out the disease resistance program.

3. Neither the breeder nor the pathologist can undertake the resistance breeding work alone. A dynamic and integrated program implemented through the joint effort of plant breeders and plant pathologists is necessary. The existing administrative barriers between these two groups should be removed before proceeding with the promotion of this program.

4. Technical priority should be given to the following studies:

a. The genetic relationship between the host and the pathogen and the disease inheritant pattern of the host. These may provide some information basic to the screening of the germ plasm for new sources of resistance, to the selection of parents in hybridization and to the understanding of the causes of occurrence of new pathogenic races.

b. The development of an effective artificial inoculation method or some means to control the environment for increasing the inoculum, so that the screening work will not rely completely on the existing natural infection method. A saving of time, labor and money and a condition of uniform disease infection can thus be assured.

c. The causes and patterns of the variability of several important destructive pathogens.

Although the progress of a disease resistance breeding program may be slow requiring a considerable amount of investment, yet a well-organized program to be actively supported by the government should be initiated as soon as possible.

CROP IMPROVEMENT PROGRAMS CONDUCTED ON KINMEN

Chih-Kang Chao

Geography and History

The Island of Kinmen composed of "Big Kinmen", "Small Kinmen (Lieh-yu)" and several other islets is located 15 kilometers off the harbor of Amoy on the mainland.

Its original name was Wuchow (浯洲) or Hsienchow (仙洲) prior to the use of the present name "Kinmen" in the early part of the Ming (明) Dynasty.

According to historical records, the first batch of settlers on Kinmen consisted of six families during the Chin (晉) Dynasty (265-419). They went there to seek refuge from a civil war. With the growing number of settlers from the mainland, Kinmen was put under the jurisdiction of Tungan Hsien (同安縣), Fukien Province during the Tang (唐) Dynasty. It was only after the Chinese Republic was established that Kinmen became an independent county in 1914.

Agricultural Conditions and Crop Production in Previous Years

Since the island has no natural shelter, it is affected by the strong northeast winds during the winter. The average annual rainfall is around 1,000 mm mostly accounted for during the rainy season from April to September. Though Kinmen lies at the same latitude as Taichung, yet it has a mean temperature of 21°C which is similar to that of Taipei.

According to a survey made by the Taiwan Agricultural Research Institute, most of the Kinmen soil is red to light yellow sandy soil and loamy sand with low water-holding capacity and low fertility. The soil is slightly acid to neutral, lacking organic matter and containing little available phosphorus and potassium.

Kinmen was formerly regarded as a barren area where only a few crops were grown with poor yields. What the settlers produced from the soil could only last them about eight months, so the able-bodied islanders took to fishing and trading overseas to earn enough money to support their families on the island. Remittances from overseas had been the main source of income for the islanders.

Crop Improvement Programs Initiated by JCRR

In an attempt to raise the living standard of the island population, JCRR set up an Advisory Committee in Aid of the Outlying Islands in 1952. The aid programs for Kinmen included improvement of crop production, livestock industry, rural health, fishery, forestry, water supply, land reform, rural education and agricultural organizations.

The crop improvement projects were carried out through the following three channels:

A. *Establishment of an agricultural experiment station*

Starting with only a one-room office and less than one hectare of land, the Kinmen Agricultural Experiment Station gradually expanded with JCRR assistance in setting up an office building, laboratories, warehouses, the necessary experimental facilities, meteorological equipment, and a branch station at Houlung, totalling 16 hectares.

B. *Initiation of varietal improvement and cultural experiments on various crops*

Numerous new varieties of field crops, vegetables and fruits were introduced into Kinmen for selection and adaptation testing before extension. The improvement of cultural practices included pest control and chemical fertilizer application, which represented an absolutely new approach to farming for the islanders in the early 1950's. Crop specialists of JCRR and the agricultural stations in Taiwan concerned made frequent visits to Kinmen to help the local agricultural workers conduct field experiments.

C. *Conducting field demonstrations and extension on crop improvement through the Kinmen Farmers' Association*

The farmers' associations on Kinmen established in 1951 came into effective operation two years later when JCRR began to render assistance to the strategic island. The program strengthened the farmers' organization by donating physical facilities, training selected personnel for the Kinmen FAs, conducting various field demonstrations and extending activities of major field crops, vegetables and fruits. Training classes for the farmers to learn new agricultural techniques were held in the crop season each year.

Achievements in Crop Production Promotion

A. *Increase of crop production*

With the cooperation of the Kinmen Agricultural Experiment Station and the Kinmen Farmers' Associations and the all-out support of the Kinmen Political Affairs Commission and the Kinmen Hsien Government, most of the major crop production on Kinmen increased significantly in recent years as shown in the following table:

Crop	1950-52 average			1961			1968		
	ha	m.t.	kg/ha	ha	m.t.	kg/ha	ha	m.t.	kg/ha
Sweet potatoes	1,134 (100)	8,511 (100)	7,542 (100)	2,330 (205)	34,950 (411)	15,000 (199)	1,982 (175)	22,524 (265)	11,364 (150)
Peanuts	763 (100)	433 (100)	608 (100)	1,138 (149)	700 (162)	615 (101)	676 (89)	385 (89)	570 (94)
Sorghum	68 (100)	67 (100)	911 (100)	475 (699)	864 (1,290)	1,819 (200)	643 (945)	1,272 (1,898)	1,978 (217)
Barley	151 (100)	59 (100)	486 (100)	388 (257)	359 (608)	925 (190)	585 (387)	761 (1,290)	1,301 (268)
Wheat	309 (100)	88 (100)	381 (100)	82 (27)	219 (249)	375 (98)	83 (27)	69 (78)	831 (218)
Vegetables	44 (100)	190 (100)	3,753 (100)	707 (1,607)	19,151 (10,079)	27,088 (722)	1,431 (3,252)	15,369 (8,089)	10,740 (286)

As shown in the table above, the production in 1968 increased 1.65 times for sweet potatoes, about 18 times for sorghum, 13 times for barley and 80 times for vegetables, when compared with the 3-year average of 1950-52.

B. Development of new crops

Taking corn as an example, there was no commercial corn production on the outlying islands before 1960. However, corn has now become one of the major crops with an acreage of about 600 ha producing about 2,000 m.t. a year as the result of successful introduction and trial planting of hybrid corn. As for vegetable growing, formerly Kinmen could only produce a few kinds of vegetables in limited quantities. Now more than 30 kinds of vegetables are grown to supply the daily needs of the island population.

Watermelon, onion, tomato and cauliflower are quite new to the local consumers, and pea production has increased to such an extent that it is exported to Taiwan for sale. The most striking example of success in recent years is fruit tree planting. Through the efforts of the Kinmen AES, more

Table 1. Hybrid corn production on Kinmen

Year	Acreage (ha)	Production (m.t.)	Unit yield (kg/ha)	Year	Acreage (ha)	Production (m.t.)	Unit yield (kg/ha)
1959	0	0	0	1964	457	1,304	2,854
1960	30	119	3,498	1965	496	1,623	3,272
1961	59	149	2,537	1966	392	1,207	3,079
1962	133	492	3,468	1967	626	2,510	4,009
1963	569	286	503*	1968	454	1,691	3,725

* Low yield due to frost and prolonged drought.

Table 2. The planting record of fruit trees on Kinmen 1961 - 1968

	Longan	Guava	Papaya	Grape	Citrus[1]	Mango	Lichi	Others[2]
1961	—	6,200	2,000	—	—	—	—	—
1962	150	—	3,000	500	—	—	50	50
1963	1,330	100	1,500	200	200	700	365	55
1964	10,000	5,800	8,000	3,000	955	500	1,000	800
1965	1,000	6,500	8,000	6,064	1,270	3	—	803
1966	825	8,654	9,869	7,169	2,907	—	—	2,843
1967	2,739	12,361	1,110	4,019	3,012	280	371	12,193
1968	1,939	7,506	—	650	871	9,950	194	12,049
Total	17,983	47,121	33,479	21,602	9,215	11,433	1,980	28,793
	171,606							

[1] Including tankan, ponkan, lemon and pomelo.
[2] Including peach, plum, pear, persimmon and other fruits.

than 20 kinds of fruit trees have been introduced to Kinmen since 1950 for adaptation trial planting. Whenever proved suitable for local cultivation, guava, grape, papaya, mango and longan have been recommended for culture to the local farmers. The total number of fruit trees grown at the Station and on private farms has been increased to some 172,000 within a period of eight years. Grape, guava and papaya are now grown on a commercial scale. According to field experiments undertaken in the past two years, tobacco will be another promising crop for the irrigated sandy soil on Kinmen.

C. Raise of living standard

The living standard of the Kinmen people has been much improved with the promotion of crop production, and the fast development of livestock and poultry farming due to sufficient supply of locally produced feed. The living conditions of the local farmers improved with increased income from crop yields and the cultivation of new crops of high economic value. The non-farming inhabitants are also enjoying cheaper and better food, such as abundant supplies of vegetables, fruits, pork, chicken and eggs, which were formerly imported from Amoy before 1949 and subsequently from Taiwan at high prices until Kinmen became self-sufficient.

Furthermore, increased production of sorghum led to the development of the famous, lucrative Kinmen Kaoliang wine which enabled the Kinmen Government to allocate enough funds to start the 9-year compulsory education four years ahead of Taiwan.

Prospects for Further Improvement

In spite of the accomplishments mentioned above, there is still much to be done for greater crop production improvement. Some of the obvious means of further improvement are enumerated as follows:

1. Sorghum yield can be doubled by growing hybrid sorghum and adopting ratoon cultivation. The local sorghum varieties are still poor in yield capacity and ratoon ability. The growing of only one crop a year produces an average of no more than 2.0 m.t. per ha. According to experimental results and trial planting, the sorghum output can be greatly increased if the old varieties are replaced by hybrid sorghum which can be grown twice a year by ratoon cultivation to yield more than 3.0 m.t. per ha for each crop.

2. Crop production can be further increased through the proper use of chemical fertilizers. The increased use of chemical fertilizers from 60 m.t. in 1950 to 2,057 m.t. in 1968 was undoubtedly one of the important factors in the high unit yields of crop production. However, most of the Kinmen farmers are still negligent in using sufficient quantities of phosphorus and potassium, especially potassium chloride, as shown in the following table. Only the application of nitrogen fertilizer has shown an increase in recent years. The soil on Kinmen contains very low amounts of available phosphorus and potassium which have to be supplemented in sufficient amounts for adequate crop growth. It is obvious that efforts have to be made to teach the island farmers the use of proper amounts of different chemical fertilizers for different crops to enhance production.

Table 3. Data on chemical fertilizers used on Kinmen
1950 - 1968

(unit: m.t.)

Year	Total	Ammonium sulphate	Calcium superphosphate	Potassium chloride
1950	60	60	0	0
1951	80	60	20	0
1952	171[1]	—	—	—
1953	1,286	680	445	161
1954	697	363	254	80
1955	568	309	195	64
1956	1,092	567	409	115
1957	921	498	353	71
1958	949	552	333	63
1959	699	596	93	9
1960	886	735	132	19
1961	1,072	886	175	11
1962	1,169	958	197	13
1963	1,282	989	270	21
1964	1,364	1,069	282	13
1965	1,821	1,391	417	13
1966	1,764	1,359	390	16
1967	1,774	1,360	398	15
1968	2,057	1,558	465	15

[1] Mixed fertilizer.

3. The development of new crops of economic importance needs to be further enhanced. In view of the promising results obtained from preliminary experiments on tobacco cultivation on Kinmen sandy soils, further field tests on its ecological and environmental adaptation should be carried out to find out the most desirable varieties and cultural practices. To ensure success in the production of adaptable fruit trees, such as grape, guava, mango and longan, the possibility of developing a fruit-processing industry should be explored, because very soon the small island of Kinmen will produce too much fresh fruits for local consumption, so an outlet for marketing surplus fruits has to be considered.

REPORT ON PARTICIPATION IN SEMINARS ON WORLD FOOD PROBLEMS; OBSERVATION OF MUSHROOM AND ASPARAGUS PRODUCTION IN USA; AND TEA AND SILK INDUSTRIES IN JAPAN

Chi-Lin Luh

Workshop at Cornell University

This workshop was held from March 30 to April 3, 1970 at Cornell University with participants from FAO, World Bank, USAID, USDA, Ford Foundation, universities of many states in the U. S. and also from other countries such as India, the Philippines, Kenya, Mexico, Thailand, Colombia, Canada and the Republic of China. The topics discussed during the workshop covered a wide range, from the production of grains, specialty crops to farm management and marketing of farm products. It was unanimously agreed that more coordinated programs should be planned through better understanding of food production among developed and developing countries.

During the workshop I had the opportunity to show the audience some 70 slides related to specialty crop production in Taiwan and samples of our mushroom, asparagus and baby corn packed in jars, in addition to present my condensed report on specialty crops of Taiwan. Evidently my report impressed the audience favorably, not only because of the aid of color slides and samples, but also on account of the world-wide reputation gained by our agricultural improvement programs in the past two decades.

I was particularly happy to hear the speeches made by Dr. F. F. Hill of the Ford Foundation, Dr. Gilbert Levine of Cornell University and several others who frequently cited as example the successful programs or projects developed in Taiwan. The organization of irrigation associations and farmers' associations, the development of new crops for export and our contributions to the international agricultural training programs and technical assistance to other countries were highly commended by the participants many of whom had visited Taiwan in the past.

In the last part of my report I pointed out that in spite of our past accomplishments, we are still facing many new problems, such as the urgent need of instituting an efficient farm mechanization program to keep pace with rapid industrialization, the need of technical know-how for fuller utilization of slope land and the development of post-harvest handling techniques of fruits and vegetables in order to modernize our marketing system. Thus technical as well as financial assistance from abroad is still necessary from time to time.

Seminar on Food Problems in Asia and the Pacific

Sponsored by the East-West Center, the Seminar on Food Problems in Asia and the Pacific was held in Hawaii on May 13-15, 1970 and attended by 58 participants, including 4 from the Pacific islands, 10 from the U.S. mainland, 16 from Asian countries and 28 from the University of Hawaii.

The topics discussed centered on the following subjects:

1. Review and outlook of the food situation
2. Better food for the increasing millions
3. Food technology in economic development
4. Problems of food trade and finance
5. Food and human value
6. Implementation by the East-West Center of a system approach to the problem of food

After the three-day meeting, the participants reached a better understanding of the basic nature of the seminar. They were:

1. Cooperation with technical assistance agencies in Asia and the Pacific
2. Cooperation with the University of Hawaii and other U. S. agencies
3. Suggestion of priorities concerning food problems to the East-West Center's food program

Observation of Mushroom and Asparagus Production in the U. S.

Four states in the U. S. were chosen as sites to observe mushroom production, namely Pennsylvania, Michigan, Illinois and California. The salad bowl of the U. S.—San Joaquin Valley—was also visited to observe asparagus production. Summarized in the following are my findings of these two crops.

A. Mushroom

1. The self-imposed export limit of 800,000 cases:

Before I left for the U.S. I was repeatedly informed by the trade personnel that we were not allowed to ship mushroom freely to the U. S. on account of objections from U.S. growers. Moreover, the U.S. mushroom growers were trying hard to prevent Taiwan mushroom from being exported to the U.S. through political means, and they finally succeeded in persuading our Embassy officials in Washington, D.C. to voluntarily fix the export quota to 800,000 cases a year. However, it was learned during this trip that the importation of Taiwan mushroom into the U.S. apparently did not affect the U.S. mushroom industry at all. Instead the U.S. mushroom growers stood to gain, because they could sell more of their products at a better price on account of the expanded mushroom market accelerated by the importation of Taiwan mushroom. For example, the Butler County Mushroom in Pennsylvania, the world's largest mechanized farm, has doubled its production in the past six years. Before 1966 the annual production was 16 million pounds, now it produces more than 30 million pounds a year. The California Mushroom Farm at Whittier, California, has tripled its production and sales volume when compared with those of ten years ago. The spawn maker, Dr. B. B. Stoller of Santa Cruz, California, has also tripled his spawn sales from 100,000 gallons in 1963 to 350,000 gallons in 1969 at a steady price of US$1.30 per half gallon. These facts reflect clearly that the U.S. mushroom growers and spawn makers have been substantially benefited in their business largely on account of promotional mushroom eating due to the availability of Taiwan-canned mushroom at reasonable price. Restaurants are serving mushroom dishes to make more money, and their customers would not be satisfied if mushroom does not appear on the menu.

2. Price disparity observed:

With regard to the quantity of mushroom import, it was learned that the U.S. growers have absolutely no right to establish a limit, neither does the U.S. government intend to establish such a limit provided that Taiwan exporters do not practise dumping. More Taiwan mushroom can definitely be absorbed by the U.S. market if only quality can be upgraded, and the price instead of being lower must be on a competitive level. It was noted that the Taiwan-canned mushroom on the supermarket shelves, except when marketed under the buyer's label of 'Green Giant', was sold at only 60% of the price of the U. S. product similarly packaged. Therefore, the immediate measure to be taken at present is to urge the local canners to upgrade the quality of their product while advising TMPUEC to raise export price accordingly.

3. Technical similarities and differences:

On the technical side, the operations of the specialized mushroom farms in the U. S. are all mechanized, whereas none of our growers is able to make such a heavy investment. Practically the processes used by U. S. growers in raising mushroom are identically the same as those employed in "peak-heating" under P. E. house developed in Taiwan. The only difference is in the use of animal droppings—horse and chicken manure—still extensively used by all the U. S. mushroom farms instead of synthetic compost, because horse and chicken manure is available from the numerous chicken farms and horse stables and it is much cheaper than synthetic manure. Anyway, using synthetic compost is considered to be more sanitary than animal droppings in growing mushrooms.

4. Culture medium and unit yield:

The spawn makers in eastern U.S. prefer to use rye as culture medium, but sorghum is preferred by makers in western U.S. I believe the spawn laboratories in Taiwan could make use of the locally grown sorghum for spawn making in the future to replace the manure cultured spawn. As to the yield per unit area, it was found that a wide range varying from 1.9 pounds to 3.5 pounds per square foot, averaging 2.5 pounds per square foot, is obtained by most of the growers. Under P.E. house culture, the average yield in Taiwan has reached 2.2 pounds per square foot. Price-wise the Taiwan-canned mushroom is sold at 70-80% of the U.S. products and the U.S. fresh mushroom is sold at a much higher price than that received by Taiwan growers. It varies from 40¢ to 60¢ per pound, which is at least two to four times higher than the price paid to farmers here in Taiwan. In view of increasing farm wages in the U.S., the farm operators predict the possibility of Taiwan take-over of the fresh mushroom market in the U.S. some day, especially when Boeing 747 lowers the freight charges considerably.

5. Membership to AMI:

As to the issue of inviting TMPUEC to be a member of AMI (American Mushroom Institute), I learned from this trip that members of AMI are composed of growers, packers and traders, and that the function of AMI is to supply technical information to its member growers, to appropriate funds to Pennsylvania State College for carrying out research programs and to promote the marketing of mushroom. The Institute is funded by collecting 2-3% on the products sold by its members. It was also learned that the Campbell Soup Company and the Green Giant Company, operating the second and third largest mushroom farms in the U.S., are still not members of AMI, because these two companies being technically independent see no need to be members of AMI, nor the need to promote their marketing through AMI. Judging from the above facts, it is obvious that TMPUEC has very little justification to be a member of AMI, unless it is willing to make its contribution on the condition that AMI can substantially promote and increase its present volume of Taiwan-canned mushroom in the U.S. market.

6. Further strengthening Taiwan's mushroom industry:

Among export commodities, mushroom is a comparatively new item made possible through farming technique research and export promotion through united cooperative efforts. However, this young industry can definitely be further developed and strengthened when the following recommendations are considered by the industry and government authorities concerned.

a. Amendment of TMPUEC export operation: Under the present united export system of TMPUEC, cut-throat price competition among packers and exporters has been effectively eliminated, thus stabilizing world market price and assuring a profit margin for the importers in the other countries. Consequently the world market position for Taiwan-canned mushroom is in a healthy condition. However, the weakness of this system is in affording protection to products of inferior quality packed by the poorly managed member canneries, thereby creating the problem of differences in mushroom quality. This situation should be immediately remedied by amending the system somewhat with government assistance given whenever necessary.

b. Gradual increase of export volume: The mushroom industry and the government authorities should realize the fact that although the volume of mushroom export in the past was considered large, yet one cannot as easily pick up a Taiwan-canned mushroom in the supermarkets either in the big cities or towns in the U.S. as picking up U.S.-canned ones. Besides, since TMPUEC failed to comply with the U.S. importers' demands or orders in the past, the U.S. importers have already made alternative attempts to grow mushroom in the Central and South American countries. Moreover, overseas Chinese have bitterly complained of not being able to receive ordered supplies from TMPUEC. Therefore, it is time to review the whole situation by the industry itself and the authorities concerned as to whether we should gradually increase our pack by

15-20% per year or just maintain the present pack volume. It is considered wise to increase the volume gradually for the benefit of our economy as well as to satisfy the importers in the other countries.

c. Continued support to research programs: Since the introduction of "peak-heating" experimented with P.E. house developed in Taiwan, there is marked improvement in the unit yield as well as the prevention of maggot contamination. This achievement is made possible through coordinated research programs supported by both growers and canners. Continued support is thus deemed a necessity to solve the problems we are still facing in mushroom growing. In order to educate the growers in the new technique, a special fund must be provided, to ensure a substantial improvement in mushroom quality and increase in production.

B. Asparagus

1. Changes in asparagus production in California:

a. Acreage: In the San Joaquin County alone, the asparagus acreage has been drastically reduced from 60,000 acres in 1954-55 to 28,000 acres in 1969 for two reasons, i.e., shortage of labor and competition from Taiwan-canned asparagus. Whether there will be further decrease in asparagus acreage is uncertain, largely depending on market conditions and the profit margin to be maintained by the growers.

b. Fresh and processing: In addition to the fresh asparagus market, the California-grown asparagus is also processed into canned and frozen items. Due to keen competition less asparagus is canned today, as most of the asparagus grown in California is either shipped fresh or packed in frozen form. In fact, the consumers' demand for frozen green asparagus is increasing steadily.

c. White vs. green: The production of green asparagus in the U.S. was developed only after World War II as a result of labor shortage. Much labor is required in making ridges in the asparagus field to serve as a blenching medium, a prerequisite to the production of white asparagus. The manager of a large asparagus farm estimated that only 60% of the labor is needed for the production of green asparagus as compared with that for white asparagus. In an effort to promote the marketing of green asparagus in the early 1940's, the marketing people advertised that green asparagus had higher nutritive value and this worked quite well so far. However, the green asparagus field can be easily converted to the production of white asparagus, provided there is a market demand for the latter plus the availability of labor with the price justifying the conversion. The Del Monte farm does produce a limited quantity of white asparagus but the acreage is very small compared with that for the growing of green asparagus.

d. Unit yield and method of harvest: In spite of reduced acreage, the total production of asparagus was not proportionally decreased due to increased unit yield. The yield increase is achieved through the use of better varieties and the two-row planting system instead of single-row planting. It was also noted that UC 72 has a heavier spear weight than UC 66 and that female plants produce more spears than male plants, thus resulting in higher unit yield. At present the harvesting of asparagus is still done by hand. In view of the shortage of manual labor and increased wages (US$1.20-1.25/hr. 5 years ago to US$1.75-2.00/hr. this year), the specialized asparagus farm has started using mechanical harvester. Including electronic devices, the machine costs US$30,000 per set, yet its performance is still behind expectations. The machine possesses only 40% harvesting capacity as compared with harvesting by hand. Heavy mechanical damage and skipping during harvesting makes the machine less than desirable at present.

2. California Asparagus Growers' Association:

Established in 1921 this Association has some 100-120 members, representing 75% of the total asparagus growers in the Delta area. The acreage cultivated by the members is about 60% of the total asparagus field of 23,000 acres in that area. Yet the Association is able to control 80 million pounds out of 130 million pounds of asparagus production. Especially this year (1970), the Association in its collective bargaining or group action succeeded in raising the price for its members in negotiations with buyer-processors. This is the first time the buyers have accepted the price fixed by the Association due to limited supply, weather fluctuations and the better bargaining power of the Association.

Processors can only purchase their raw material from the Association and not from individual growers. The price fixed by the Association is based on the requirements in the fresh markets, canneries, frozen plants, production, and price demanded by growers. There is practically no need of government assistance in settling the issues concerning the buying and selling of asparagus.

3. Prospects for expanded marketing of Taiwan-canned asparagus:

As a whole, asparagus, whether white or green, has long enjoyed a steady market in the U.S. Therefore it is usual for U.S. housewives to buy quality asparagus at reasonable price. In other words, there is a constant market demand for asparagus in the U.S. However, the promotion of our asparagus export trade still faces many problems, such as variety, cultural method, harvesting and handling, processing, packaging, pricing, storage and marketing. Yet it seems to me that the most important work for us to do now is to achieve uniformity in quality and united export trade. Without coordinated effort in the promotion of export trade and failing to attain uniformity of commodity, the market of either white or green asparagus in the U.S. can be easily taken away by suppliers from other countries. The processors in the U.S. have already indicated their reluctance to import asparagus of variable quality and unstable price from Taiwan and are already seeking other sources of supply such as Mexico and the Central American countries. Consequently it is a matter of great importance for us to organize our processors and exporters to fortify our export trade in the immediate future and to strengthen research on asparagus farming and marketing in order to upgrade this export commodity and uphold its reputation in the international market.

Observation of Silk and Tea Industries in Japan

The main purpose of my visit to

the silk and tea research stations in Japan is to familiarize myself with their advanced technical knowledge as a reference for our improvement programs in the future. It is my firm belief that the development of Taiwan's silk industry can be greatly stepped up through implementation of our government policy of slopeland cultivation, and that there is plenty of room for improving our tea industry, thus further increasing the volume of export trade.

Japan was for a time a large exporter of silk and tea in the international market. However, due to rapid industrialization, the export of silk and tea from Japan has become practically nonexistent. Instead they have become import commodities now.

	Silk	Tea
Past export:		
Pre-war volume	300,000 tan (@tan=60kg)	10,117 m.t. (1960)
Value	US$300 million	US$569 million
Present export:		
Volume	1,300 tan	1,664 m.t. (1969)
Value	US$3 million	
Present import:		
Volume	43,000 tan	11,608 m.t. (1969)
Value	US$47.3 million	

The importation of both silk and tea by Japan is inevitable due to rapid economic development, mounting population growth and increased consumption, while production can not meet market demands, regardless of increased unit yield and mechanized farm operations. Nevertheless, the government is working hard toward increasing production efficiency through agricultural research and organizational reforms. Since Japan has succeeded in attaining self-sufficiency in rice consumption, many government officials are confident that they could produce 40,000 m.t. of surplus tea by 1972 and develop the silk industry in western Japan where the pressure of industrialization is less intense and the vast slopeland can be utilized for this purpose.

After my brief observation in Japan, I realized that the rate of our tea production is only 30-50% of that in Japan, and that the Japanese tea growers are applying more organic fertilizers to tea bushes than their counterparts in Taiwan. A program of improved tea culture for immediate extension to tea growers is thus urgently needed to achieve rapid increase in unit yield at an early date. Therefore careful studies should be made of the effective examples now employed by the tea and silk industries in Japan to serve as very valuable reference for us.

POST-HARVEST PHYSIOLOGY, HANDLING, TRANSIT AND STORAGE OF FRESH FRUITS AND VEGETABLES

Fu-Wen Liu

What Is Post-harvest Physiology?

Horticulturists, fruit and vegetable dealers as well as consumers are often confronted with the problem of rapid deterioration of fresh fruits and vegetables. Before discussing the techniques employed nowadays for the prevention of too rapid deterioration of fresh fruits and vegetables thus prolonging their storage or shelf life, let us find out what is going on or what physiological processes are taking place in the fruits and vegetables after harvest. The main post-harvest physiological processes are as follows:

1. Transpiration—Transpiration means the loss of water in vapor form from the living cells. Loss of too much moisture will cause desiccation of fruits or vegetables.

2. Respiration — Besides gas exchange, oxidation of carbohydrates and heat elaboration are important from both the physiological and the practical points of view. Rapid respiration causes rapid senescence of the harvested fruits and vegetables.

3. Ripening—In such fruits and vegetables as bananas, papayas, cantaloupes, etc., the ripening process starts right after harvest.

4. Biochemical changes.

5. Chilling injuries.

Temperature, humidity, gas component of the ambient air as well as mechanical injury of fruits or vegetables exert great influence over the above-mentioned physiological processes. To regulate the rate of the physiological processes, thereby preventing fresh fruits and vegetables from deteriorating rapidly for advantageous transaction as well as minimizing market loss, the following marketing practices are necessary:

1. Handling — Trimming, grading, pre-cooling, fungicidal treatment, waxing and packaging.

2. Transit—Adequate facilities to provide the desired environmental conditions and to protect the commodities from mechanical damage.

3. Storage — Practice of common storage, cold storage, or controlled atmosphere storage according to need.

Better understanding of post-harvest physiology and improved handling, transit and storage techniques is prerequisite to modernization of fruit and vegetable marketing.

What Improvement Work Has Been Done by JCRR in the Past?

1. In 1957, JCRR assisted the College of Agriculture, NTU and PDAF, in conducting training classes on im-

proved technique of fruit and vegetable grading and packaging. Technical workers of the agricultural agencies concerned attended the classes.

2. In 1960, JCRR provided cold storage facilities for the Department of Horticulture of NTU, the Taipei District Agricultural Improvement Station and the Fengshan Tropical Horticultural Experiment Station in carrying out research on post-harvest physiology and cold storage techniques.

3. In the early years of the last decade JCRR assisted in training citrus fruit growers in proficient harvesting methods, improvement of packing house facilities and techniques of handling and packaging citrus fruits for export.

4. Many research projects such as (a) studies on adequate packaging and storage methods for selected vegetables (Taipei DAIS); (b) studies on post-harvest physiology and decay control for bananas and mandarins (NTU); (c) studies on the method of hot water treatment for decay control of mangoes (Fengshan THES); (d) studies on desirable maturity and transit temperature for export pineapples (Fengshan THES), etc. have been carried out by the various research organizations with JCRR assistance.

5. In the spring of 1969, two U.S. marketing specialists, Messrs. E. H. Myers and C. B. McMillan, were invited by JCRR as short-term consultants to study ways and means of improving vegetable handling, grading, packaging and marketing in Taiwan. Valuable recommendations were made by them in their report.

Comparison of Fruit and Vegetable Handling and Marketing Situation in Taiwan with That in the Other Developed Countries

When compared with other developed countries like the U.S., the facilities as well as techniques employed in fruit and vegetable handling and marketing in Taiwan are rather crude. There is practically no grading of fruits and vegetables in the local markets. The products are not properly trimmed and packed. Besides, rough handling causes considerable mechanical damage, and most of the wholesale and retail markets are too crowded, disorderly and unsanitary. So there is an urgent need to remedy the situation immediately.

What Projects Are Required in the Immediate Future?

1. Strengthening of research—Fundamental studies on post-harvest physiology of various kinds of fruits and vegetables are as important as applied research on feasible techniques of improved handling, storage and marketing of perishable products. The former will provide basic data needed in developing the latter. Several existing laboratories in the agricultural institutions in Taiwan should be reactivated and their research work strengthened with JCRR assistance. New laboratories should also be established whenever necessary.

2. Trial and extension of improved techniques—Standards for grading important vegetables and fruits for the local market have to be worked out and better containers made of wood or plastic material will be tested. Integrated improved methods of grading,

hydro-cooling, better trimming and packaging of fresh vegetables will be first tried out in the assembling markets in the Yuanlin area in FY1970. Whenever such improved methods are proved to be beneficial and practical, they will be extended gradually to the other vegetable producing and packing centers.

3. Training of more post-harvest physiologists and handling specialists— The biggest handicap in promoting the above-mentioned work is the shortage of well trained technical workers. Therefore, training of more post-harvest physiologists and handling and marketing specialists is urgently needed. Junior technicians may be trained in laboratories, agricultural stations, or agricultural colleges in Taiwan, while senior technical workers may be sent abroad for advanced training.

MUSHROOM PRODUCTION IN TAIWAN

Ching-Wu Shen

Introduction

Mushroom is a temperate zone crop which thrives in a cool climate. The most important mushroom-producing centers in the world are all located in the temperate zone countries, such as France, West Germany, United States of America, Canada, Japan, etc.

Table 1. Canned mushrooms packed by specified countries

Unit: 1,000 cases/(24/303s)

Countries	1962	1963	1964	1965	1966	1967	1968
France	2,427	2,660	2,763	3,183	3,563	4,553	
W-Germany	312	285	203	435	407	454	
U.S.A.	1,917	1,833	1,772	1,907	1,921	1,965	2,170
Canada	184	194	237	420	485	596	
Japan	147	171	68	86	125	199	
ROC	1,828	2,502	2,214	3,155	3,029	4,668	3,493

Source: Taiwan Export of Canned Food, 1968

Production

In subtropical Taiwan, mushroom growing once seemed out of the question, to say nothing of competing with the other mushroom-producing countries on the international market. However, we have now succeeded in turning the island into one of the leading mushroom exporting countries within a short period of three years (1953-1956).

The phenomenal growth of mushroom production in Taiwan is shown in Table 2.

Those factors instrumental in the rapid development of the mushroom industry in Taiwan are:

1. The season for mushroom growing fits in exceptionally well with the slack season of farming in Taiwan, thus the idle hands in the farmers' families can be fully utilized.

2. Cheap materials, such as rice straw for compost manufacturing and bamboo for building mushroom house, are available all over the island.

3. The limited space required for mushroom growing presents very little or no competition with the production of other food crops.

4. The production season of mushroom and pineapple or asparagus can be so adjusted that optimum utilization

Table 2. Planted acreage and production of mushroom

Year	Planted acreage (ping[1])	Yield per ping (kg)	Production (MT)
1956–57	4,000	15.00	60
1957–58	80,000	15.00	1,200
1958–59	60,000	16.00	960
1959–60	45,000	16.00	720
1960–61	195,000	16.00	3,120
1961–62	980,000	16.00	15,680
1962–63	2,419,543	15.97	38,639
1963–64	1,799,480	12.62	22,718
1964–65	2,590,969	12.52	32,430
1965–66	3,499,050	10.99	38,454
1966–67	3,666,884	13.68	50,181
1967–68	3,790,420	13.82	52,400
1968–69	2,417,266	13.56	32,767

[1] 1 ping = $3.3 m^2$ = 0.00082 acre
Source: Taiwan Agricultural Yearbook, 1969

Table 3. Cost of Taiwan mushroom production in 1968

Item	NT$/100 ping	%
Spawn	2,069	8.81
Fertilizers	6,968	29.67
Labor	9,773	41.62
Pesticides	265	1.13
Material	260	1.11
Mushroom house	2,061	8.78
Farm implements	230	0.98
Tax	1,400	5.96
Interest on land	18	0.08
Interest on capital	437	1.86
Total	NT$23,481	100.00

Source: A Survey of Costs of Agricultural Production in Taiwan, 1969

of canning factory facilities can be attained.

5. The farmers' organizations in Taiwan serve as disseminators of technical know-how of mushroom growing among the farmers.

Export

Through diligent efforts of Taiwan farmers and technical guidance of agricultural research institutes and stations, the export of some two million cases of canned mushrooms annually has been the object of envy to foreign mushroom growers. This is no miracle, but an outstanding case of success in the application of agricultural science through close cooperation of agricultural workers under the technical and financial assistance of JCRR.

Table 4. Volume and value of canned mushrooms exported since 1958

Year	Export quantity (std. case[1])	Export value (US$)	Year	Export quantity (std. case)	Export value (US$)
1958	68	681	1964	1,171,936	15,604,971
1959	200	2,800	1965	1,606,182	20,481,233
1960	14,606	150,406	1966	1,845,310	25,085,204
1961	146,554	1,797,653	1967	2,303,439	32,228,364
1962	709,281	8,507,720	1968	2,319,881	30,353,528
1963	1,377,658	16,148,478			

[1] 1 standard case=21.81kg
Source: Taiwan Exports of Canned Food, 1969

Table 5. Quantity and value of canned food products exported in 1968

Commodity	Export quantity (std. case)	Export value (US$1,000)
Pineapple	3,780,382	18,974
Mushroom	2,319,881	30,354
Asparagus	2,136,386	28,827
Bamboo shoots	1,032,092	4,275
Mandarin orange	411,356	2,303
Water chestnut	251,309	1,304
Others	283,910	2,166
Total:	10,215,316	88,203

Source: Taiwan Exports of Canned Food, 1969

Accomplishments of Mushroom Research

1. Success in synthetic compost experiment: In Taiwan, synthetic compost prepared with rice straw is used instead of horse manure.

2. Use of rice straw house: A mushroom-growing house built with rice straw and bamboo poles greatly reduces production cost.

3. Selection of quality spawn: The mushroom specialists have succeeded in developing heat-tolerant, early maturing varieties of spawn suitable for use in Taiwan.

4. Improvement of cultivation techniques: The improved techniques have been proved quite convenient and acceptable to mushroom growers.

5. Functions of the Committee on Mushroom Research: The Committee is credited with the set-up of a sound mushroom research system, installation of mushroom research equipment and subsidization of research agencies concerned.

ONION PRODUCTION IN TAIWAN

Ching-Wu Shen

Introduction

On account of our high humidity and high temperature for the greater part of the year, Taiwan was not considered suitable for growing onion on a large scale. Prior to 1954, no attempt was made to raise onion on this island, and all the onions consumed locally were imported from Japan, costing the nation some US$400,000 in foreign exchange every year.

With a view to attaining self-sufficiency in vegetable production, JCRR vegetable specialists as early as 1950 began collecting onion varieties from other countries, analyzing the climatic conditions in all parts of the island and conducting trial plantings in areas where the soil and climatic conditions were suitable for the growing of onions. Eventually the conclusion was reached that it was possible to produce onion in Taiwan, particularly in the south, if the right varieties were chosen and planted under the right climatic conditions.

Production

JCRR, in cooperation with the Taipei DAIS, the Fengshan THES and other agricultural institutes, initiated in 1950 a project to study the proper cultural methods of onion production in Taiwan. In 1951, the Taipei DAIS succeeded in selecting two adaptable, high-yielding varieties, Early Grano and Excel Bermuda, from among those introduced. In the following year, the Fengshan THES carried out a regional adaptability test with the selected varieties and found that the Kaohsiung-Pingtung area in south Taiwan, with its dry, cool winter season, was suitable for growing these two varieties. A record yield of 6,000 kg/ha that year was a real surprise to the vegetable experts throughout the world. The foundation for onion production in Taiwan was thus firmly established.

Table 1. Acreage and production of onion

Year	Planted acreage (ha)	Yield per unit (kg/ha)	Production (M.T.)	Year	Planted acreage (ha)	Yield per unit (kg/ha)	Production (M.T.)
1955	200	10,000	2,000	1963	696	28,660	19,960
1956	1,144	10,850	12,409	1964	1,925	32,724	62,976
1957	617	12,742	7,867	1965	577	33,437	19,293
1958	570	11,689	6,663	1966	719	25,873	18,614
1959	389	14,072	5,480	1967	595	37,717	22,440
1960	511	22,424	11,457	1968	674	37,960	25,603
1961	362	25,069	9,079	1969	1,005	31,047	31,191
1962	424	18,941	8,034				

Table 2. Planted acreage and output of onion in 1969

County	Acreage (ha)	Production (M.T.)
Pingtung	619	18,510
Taitung	220	8,311
Kaohsiung	58	2,059
Chiayi	57	1,047
Tainan	31	816
Other areas	20	448
Total	1,005	31,191

Table 3. Cost of onion production in 1969

Item	NT$/ha	%
Seedlings	3,810	11.3
Fertilizers	7,835	22.6
Labor	16,484	47.6
Pesticides	1,253	3.6
Materials	286	0.8
Irrigation	1,603	4.6
Packing house	253	0.7
Farm implements	280	0.8
Tax	625	1.8
Interest on land	1,494	4.3
Interest on investment	651	1.9
Total	34,574	100

Research

Since onion is a new crop in Taiwan, a team of vegetable workers from agricultural colleges and experiment stations joined hands in studying and solving the various problems encountered in onion production, such as planting distance, the amount and timing of fertilizer applications, pest control and post-harvest, handling and packing.

Through research the following techniques of onion culture have been formulated:

1. Sowing time: The optimum time for sowing seeds for transplanting is from mid-September to mid-October. Within this period, early sowing usually results in higher percentage of bulb division, while late sowing produces lower percentage of bulb division.

2. Plant distance: Wider spacing usually means larger bulbs, lower unit yield and higher percentage of bulb division. To produce medium-sized bulbs to meet the Japanese market requirement, the 22cm x 9-10cm spacing is recommended.

3. Seedling size: Under the same seedling age, large seedlings usually produce larger bulbs than small seedlings. However, the former has a higher percentage of bulb division than the latter.

4. Seedling age: Within the age limit of 25 to 60 days, the younger seedlings usually bring about earlier bulbing, earlier maturity and larger bulbs. However, onions developed from 40-day-old seedlings give the lowest percentage of bulb division. Therefore, 40 days is the optimum age for transplanting.

5. Onion grown with dry sets: Within the range of 1-3.5 cm in diameter, larger onion sets usually produce plants of earlier maturity, higher yield, and higher percentage of bulb division. The optimum date for planting onion set is from mid-September to early October. The most desirable plant spacing is 20-25 cm between rows and 9-12 cm in row, depending on the size of onion sets.

6. Weed control with herbicides: Applying herbicide TOK E-25 to the onion seedbeds once immediately after

the seed was sowed and covered with a thin layer of soil showed good weed control. The same effect was also observed on weedy fields where herbicide was sprayed on the soil surface between rows immediately after first cultivation and top dressing.

Export

In 1956, onion was produced in such quantity that it was not only enough for local consumption, but could also be exported to Hongkong and Southeast Asian countries for the first time in Taiwan history. As cultivation techniques further improved and planted acreage increased, large quantities of onion have been shipped to the Ryukyu Islands and Japan since 1962. The shift from an importer to an exporter to gross more than a million dollars of foreign exchange for the country serves as an apt example of success in agricultural production in Taiwan.

Table 4. Export volume and value of onion

Year	Export volume (M.T.)	Value (US$1,000)	Year	Export volume (M.T.)	Value (US$1,000)
1956	328	—	1963	19,625	1,664
1957	499	—	1964	30,297	2,303
1958	241	—	1965	8,919	1,022
1959	457	—	1966	7,266	658
1960	458	—	1967	9,559	1,102
1961	813	—	1968	14,269	1,630
1962	4,871	365	1969	10,413	1,200

Further Development

There is still room for development in the onion industry for greater efficiency and more advantageous competition in the international market. The following improvement measures are recommended for adoption:

1. Introduction and selection of the red skin, pungent varieties for export to Southeast Asian countries.

2. Development of varieties good for storage for local consumption.

3. Mechanization of onion cultivation to offset labor shortage and cut down cost of production.

4. Efficient storage, marketing and transportation systems to be set up in the major onion-producing areas.

5. Efficient means of controlling onion pests and diseases.

GRAPE PRODUCTION IN TAIWAN

Kuo-Liang Chang

Following the successful production of such temperate zone deciduous fruits as pears, apples and peaches at high altitude, the cultivation of grapes has been developed so rapidly in the past several years that grape vines are even planted in paddy fields, thanks to the varietal selection and cultural research carried out by agricultural institutions in Taiwan.

It is worth our while to review the history of grape growing on this island and to take a bird's-eye view of the production situation, besides discussing the problems the grape industry is facing or will be facing in the near future.

Historically grape (*vitis* spp.) is a popular delicious fruit native to the southern shore of the Caspian Sea in the Middle East. It was introduced into mainland China as early as 120 B. C. when the first imperial trade mission was sent to explore the "Western Regions" and on their return trip brought back, among other things, grape vines. Soon it became a popular practice to grow grape in North China.

According to the historical records of Taiwan, grape was cultivated on a very small scale in northern Taiwan in 1925. It was only grown in family gardens for home consumption. Soon after the site of the Central Government was moved to Taipei in 1949, JCRR took the initiative to promote grape production, especially when the demand for grape wine was high and the Taiwan Tobacco & Wine Monopoly Bureau (TWMB) was looking for more raw material for wine making.

Through years of effort by JCRR, TWMB and NTU on varietal selection and improvement of cultivation technique, the planted acreage was expanded from 20 ha in 1957 to 400 ha in 1963, a twenty-fold increase in six years. The grape grown was mainly for wine making and the varieties recommended were confined to Niagara and Golden Muscat varieties. However, when trial planting of other varieties proved successful, they were extended to farmers for general planting. It was only three or four years ago when the taste for fresh grapes became so strong that the grape growers began to reap large profits, thus accounting for the expanded planted acreage from Miaoli and Hsinchu to Changhua, Chiayi and as far south as Tainan. Now people travelling by train may see trellised grape vines here and there along the railway lines in central Taiwan.

The following table shows the rising trend of grape production since 1960:

Year	Harvested area		Production		Year	Harvested area		Production	
	ha	Index	M.T.	Index		ha	Index	M.T.	Index
1960	199	100	1,718	100	1966	454	228	3,784	220
1961	201	101	1,831	106	1967	487	244	4,858	282
1962	226	113	2,200	128	1968	563	283	6,801	395
1963	252	126	2,120	123	1969	703	353	8,468	492
1964	428	215	3,559	207	1970[1]	850	427	10,200	593
1965	386	194	3,392	197					

Source: Taiwan Agriculture Yearbook 1969

[1] An estimate by PDAF

The major grape-producing areas and the PDAF estimated planted acreage in 1970 are given below:

Area	Township	Planted acreage (ha)
Changhua	Ta-tsun, Yuan-lin, Erh-lin	300
Taichung	Hsin-sheh, Hou-li, Tung-shih, Feng-yuan, Shih-kang	200
Miaoli	Cho-lan, Kung-kuan	100
Hsinchu	Chiung-lin, Pei-pu	90
Nantou		60
Chiayi	Lu-tsao	50
Others		200
Total:		1,000*

* Including 200 ha of wine-making varieties contracted by TWMB.

There are now more than 120 varieties grown in Taiwan, including those for fresh consumption, processing and rootstocking. Most of the varieties are hybrids of two or more species. Some of the economic varieties which have been grown commercially in the past few years are described as follows:

1. Kyoho (巨峯)—The most popular variety grown on this island, fruit purple, vine vigorous, widely adaptable and productive, medium variety, excellent for table use.

2. Royal Red (紅冠)—Light purple, vigorous vine, widely adaptable, medium variety, excellent for both table use and shipment.

3. Italia IP 65—Large, yellow fruit, large clusters, excellent for table use.

4. Buffalo (六月鮮)—Fruit purple, vine vigorous and productive, early maturity, high sugar content, good for table use.

5. Muscat Baily A—Fruit purple, vine vigorous and highly adaptable, small fruit and large clusters, late maturity, excellent quality, good for both table use and shipment.

6. Niagara—Most popular white-fruit variety, large fruit and clusters, fruit moderately acid, medium in sugar content, production constant, mostly used for wine making.

7. Golden Muscat (金香)—Vine vigorous and extremely productive, large, well-filled clusters of yellow, juicy fruit with a distinctive, sometimes mild, pleasing muscat flavor. Excellent for table use and wine making but poor for shipping.

8. Neo Muscat (新玫瑰香)—Extremely vigorous with high productivity, fruit yellow with very fine texture, medium and late variety of good quality suitable for juice and wine making but not for table use.

9. Concord—Highly adaptable, disease resistant and productive, large fruit and medium large clusters, purple fruit, highly fragrant, has a "foxy" flavor, good for making juice.

Now that the grape growers are enjoying a boom, it may be of interest to look into the production cost and annual returns on their investment. The following information was supplied by a grower at the Ta-tsun Township of Changhua County in July 1969.

1. Production cost for 1.0-ha vineyard:

Item	Description	Expended amount(NT$)	
		1st year	2nd year
Seedlings	Variety: Kyoho, 4,000 seedlings × NT$25/seedling	100,000	—
Erection of trellis	Horizontal trellis	60,000	—
Fertilizer & pesticide	Including manure and chemical fertilizer	20,000	30,000
Labor		15,000	20,000
Land expenses	Including rent, water and electricity	15,000	15,000
Total:		NT$210,000	NT$65,000

2. The total value of grape produced and net income obtained by the grower:

1st year: 10,000 kg × NT$14/kg = NT$140,000

2nd year: 40,000 kg × NT$15/kg = NT$600,000

Net income of growers after deducting production cost from the total value:

1st year: −NT$70,000

2nd year: NT$535,000

Grape production improvement projects carried out and/or financed by JCRR in the past 15 years are as follows:

1. Continuous experimentation on adaptability of different grape varieties introduced from abroad.

2. Studies on the effect of different rootstocks on yield and quality of grapes.

3. Experiment on the effect of different systems of training and spacing on yield and quality of some grape varieties.

4. Studies on the effectiveness of different containers for packing grapes.

5. Studies on the adaptability of outstanding grape varieties in different areas.

6. Trial planting of improved grape varieties in coastal sand-hill areas.

The sudden boom of the grape industry has highlighted many problems which have to be solved in order to clear the way for greater future development. The outstanding problems are:

1. Overproduction of grapes is foreseeable should unlimited expansion of grape planting acreage go unchecked.

2. Easy dropping of ripe fruit.

3. Poor drainage in paddy field causing poor table quality.

4. Information lacking on quality retention after harvest.

5. Inadequate research and development of techniques for processing grapes into juice, jelly, wine and canned products.

6. The need for solving problems of handling and transportation to develop foreign markets.

FRUIT JUICE PRODUCTION IN TAIWAN

Kuo-Liang Chang

Although food processing is outside my line, I would like to take this opportunity to make a brief report on the future outlook of juice production in Taiwan. There are four valid reasons for this attempt:

1. A very close connection exists between fruit production and juice production.

2. Overproduction of some kinds of fruit may be foreseen owing to the rapid utilization of slopeland in recent years mostly for growing fruit trees, thereby supplying plenty of raw materials for juice making.

3. The high living standard enjoyed by the people all over the island will give rise to greater need for highly nutritious beverages, instead of carbonated water and other artificial, synthetic liquids. The production of natural fruit juices will, no doubt, meet this requirement.

4. Natural fruit juices are always in good demand on the international market.

Bearing this objective of producing top-grade fruit juice in mind, now let us review the local production and per capita consumption of fruit juice as compared with other beverages including carbonated water in the past five years:

Table 1. Production and per capita consumption of fruit juice and carbonated water in 1964-1968 in Taiwan

Year	Carbonated water: Production: No. of large bottles (650cc)	%	No. of medium (340cc) & small (200cc) bottles	%	Per capita[1] consumption (bottle of 300cc)	Fruit juice: Production: No. of bottles	%	Per capita consumption (bottle of 300cc)
	(1,000 doz)		(1,000 doz)			(1,000 doz)		
1964	3,443	100	2,613	100	8.76	1,054	100	0.97
1965	4,049	117	3,350	128	10.56	1,243	117	1.15
1966	4,753	138	4,496	172	12.92	1,558	147	1.56
1967	5,424	158	5,386	206	14.98	2,036	193	2.03
1968	7,185	208	7,586	290	16.88	2,875	272	2.80

[1] Per capita consumption is calculated by dividing total production by the total population of 13 million.

Source: Industry of Free China, Vol. 33, No. 4.

From the above table we may make out the following facts:

1. The per capita consumption of fruit juice in Taiwan is still in its embryo stage, so there is plenty of room for developing the fruit juice industry.

2. The volume of carbonated water consumed is much larger than that of fruit juice. The 8:1 ratio of per capita consumption in 1968 means that carbonated water and other synthetic liquids have a far greater competitive power than fruit juice on the domestic market.

3. There has not been much change in the rate of increase for both carbonated water and fruit juice in the past five years.

The fruit juice industry also has a bright future where the foreign market situation of the European Economic Community (EEC), consisting of France, West Germany, Belgium, Italy, Luxembourg and the Netherlands, is shown in Table 2 and Table 3.

Table 2.
Imports of fruit juices into the EEC Market in 1963-1967

Year	Volume (ton)	Value (US$1,000)
1963	94,971	27,349
1964	103,553	29,087
1965	107,231	30,080
1966	135,992	35,034
1967	155,976	40,499

Source: Foreign Trade Analytical Tables, EEC.

The total value of the fruit juices imported into the EEC market in 1967, as shown in Table 2, amounted to more

Table 3.
Kinds of fruit juices imported into the EEC Market in 1967

Kind of fruit juice	Volume (1,000 tons)	%
Citrus fruit juice	85.7	54.9
Grape juice	39.3	24.6
Pineapple juice	13.8	8.8
Apple and pear juice	7.0	4.5
Other fruit & vegetable juice	5.9	3.8
Tomato juice	2.1	1.3
Mixed fruit & vegetable juice	2.1	1.3
Total:	155.9	99.2

Source: Foreign Trade, EEC, 1967.

than US$40 million. The average unit price of fruit juice is around US$400 per ton. When calculated in Taiwan currency, it costs approximately NT$12 for each kilogram. Although the price is not attractive as compared with that on the local market, if we can engage in mass production using the locally produced fruits and the cheap labor, we may be able to lower our production cost considerably. Moreover, as shown in Table 3, about 50 per cent of the fruit juices exported to the EEC market was extracted from citrus fruits. Here we are growing these fruits on a large scale, part of which can easily be processed into fruit juices.

Aside from those listed in Table 3, other kinds of fruit juices made from such tropical fruits as mango, guava, passion fruit, etc. when introduced into the EEC market may be potential foreign exchange earners for this country in the future. Here again, we have a vast acreage of such fruits in the central and southern parts of Taiwan. Diversification of products demanded by the world market and the rise of living standards in the EEC and other countries will serve as a stimulus to the further development of a great variety of fruit juices. Thus, the outlook for marketing new products on the international market is quite bright.

I was informed recently by those who are responsible for marketing fruit juices in the Hsinchu Fruit Marketing Cooperative that in 1968 we were asked to ship 20 thousand tons of citrus fruit juice to Japan. But we had to relinquish the offer, because we were caught unprepared. Instead, we exported some 300 boxes (each box containing 6 cans, 2.89 kg/can) of mango juice to Japan. Surprisingly it enjoyed good demand and commanded a good price at FOB US$20 per box on the Japanese market.

Judging from the above, I strongly recommend that we take prompt action to develop the embryo fruit juice industry not only for the sake of promoting people's health but also opening a new outlet to earn extra foreign exchange for the nation. However, I see many obstacles to the hoped-for development, which are listed as follows:

1. A high local turnover tax (30%) results in high production cost.

2. The artificial, synthetic beverages still hold sway in the local market.

3. Both the supply and the price of raw-materials for juice making are unstable because of the sharp competition among local manufacturers.

4. No cheaper, suitable containers are available for packing fruit juices for both the local and foreign markets.

5. There is a lack of information on fruit juice trade conditions on the foreign market.

6. Basic research on fruit juice processing, handling techniques and quality control has to be greatly strengthened.

EXPLORATION FOR HORTICULTURAL VARIETIES ABROAD

Fu-Wen Liu

Background

The pattern of export trade of Taiwan agricultural products has been changing dramatically in recent years. The annual export of rice and sugar has been dipping alarmingly, while that of banana, mushroom, asparagus and other fruits or vegetables, steadily increasing. In view of the keen competition in the international market for banana, asparagus, pineapple and other agricultural items, the development of new crops for diversification of production of export commodities and increase of foreign exchange earnings is thus deemed necessary. This can be made possible by conducting short-period explorations and observations in other countries to seek new varieties of horticultural crops for introduction into Taiwan. Development of new crops through adaptational tests, cultural experiments and extension will help enrich varietal resources of horticultural crops in Taiwan. For this purpose, a project (67-A13-A-1805) formulated in 1966 and a continuation project (70-A13-A-2025) in 1970 were approved by the Joint Commission sending two survey teams to make two separate trips abroad to explore desirable horticultural varieties.

First Trip

The Horticultural Crop Survey Team for the first trip consisted of five members, C. H. Yu, Director of the Fengshan Tropical Horticultural Experiment Station; C. K. Chu, Head of the Horticultural Department of Chiayi Agricultural Experiment Station; S. H. Lai, Junior Horticulturist of the Taiwan Seed Service; C. H. Kwong, Agronomist of the Taiwan Sugar Corporation; and C. L. Luh, the team leader and now Chief of the Plant Industry Division, JCRR.

The group left Taipei on March 24 and returned on July 15, 1967, after visiting the Philippines, Sydney (Australia), Fiji Island, American Samoa, Hawaii Islands, Mexico, Guatemala, Honduras, Costa Rica, Panama, Peru, Chile, Argentina, Brazil, Trinidad, Puerto Rico, Jamaica, and (Pennsylvania and California of the U.S.

The kinds and number of horticultural varieties collected on this trip are as follows:

Crop	Kind	No. of varieties
Fruits	53	246
Vegetables	44	268
Ornamental plants	6	61
Upland and miscellaneous crops	14	316
Total	117	891

Second Trip

The 5-member team for the second trip consisted of Y. D. Kang, Professor of the Department of Horticulture, National Taiwan University; C. K. Chu, Head of the Horticultural Department of the Chiayi Agricultural Experiment Station; C. C. Ting, Head of the Horticultural Department of the Taichung District Agricultural Improvement Station; F. W. Liu, Specialist of JCRR; and C. H. Yu, Director of the Fengshan Tropical Horticultural Experiment Station, serving as the leader of the team.

The group left Taipei on March 15 and came back on May 6, 1970. The trip lasted 52 days, covering eight countries, namely: Israel, Lebanon, Turkey, Iran, Thailand, Malaysia, Singapore and Indonesia.

The kinds and number of horticultural varieties collected during the second trip are as follows:

Crop	Kind	No. of varieties
Fruits	56	176
Vegetables	57	299
Ornamental plants	40	54
Upland and other crops	14	44
Total	167	573

Quarantine of the Introduced Plants

To meet the requirements of plant quarantine of the introduced planting materials, all plants or planting materials introduced from abroad by the Horticultural Survey Teams were accompanied by plant quarantine certificates issued by the authorized agricultural or quarantine agencies of the host countries. Upon arrival of the planting materials in Taiwan, some particular crops such as citrus, banana, sugarcane, etc., which have to be subjected to isolation tests, were sent to the Shichi Isolation Test Station of the Bureau of Commodity Inspection and Quarantine for such tests, and the rest were sent to the various agricultural experiment institutions which were entrusted to make disinfection, treatment, careful observation and adaptational tests necessary for the introduced varieties.

Follow Up Observation and Experimentation on the Introduced Varieties

All varieties introduced under this project are now under careful observation and testing at the agricultural experiment stations and agricultural colleges in Taiwan. Those varieties which are adaptable to Taiwan's climate and are of economic value will be multiplied and their cultural methods continued in experimentation. It is expected that some valuable new varieties can thus be developed, and some other varieties may serve as breeding materials.

PLANNING FOR ORGANIZATION AND TRAINING OF FARMERS IN INCREASING SUMMER VEGETABLE PRODUCTION

Yu-Tso Cheng

Technical renovation of crop production is part of the work of the Plant Industry Division, while the dissemination of such techniques to the farm population is that of the extension groups. Whether the latter is capable of working harmoniously in coordination with the former was put to the test last year when the plan for increasing summer vegetable production was formulated and carried into execution in the northern part of Taiwan.

The plan to increase summer vegetable production comprises five important items: 1) promotion of production, 2) expansion of planting areas, 3) supply of capital and materials, 4) organization and training of farmers, and 5) market survey. Of the operation fund of NT$7,000,000, NT$4,200,000 or 60 percent of the total was expended on the implementation of Items 3 and 4. From this it is evident that emphasis is placed on the extension work of organization and training and material supply through the sponsoring farmers' associations. However, in the process of launching the above activities, the following two shortcomings were found among the farmers' associations concerned:

1. Independent status of farmers' associations: The three levels of provincial, county and township farmers' associations are independent units with no official ties among them. They each hire their own men and make their own capital investments. Thus no one has authority over the others.

2. Profit motive: The extension work to be handled by a farmers' association should be remunerative. In other words, if no fund is available for handling a piece of extension work, the farmers' association may refuse to take it up.

Because of the above-mentioned shortcomings, the quality of the extension workers in the farmers' associations has been going down and the obligation of pushing agricultural extension gradually ignored by their leaders. Though a sizable amount of operation fund has been spent on the organization and training programs and the distribution of supplies and materials as formulated in the plan for increasing summer vegetable production, there was only limited progress in the extension of renovated production techniques.

Under existing government provisions, the work of agricultural extension is under the management of farmers' associations. However, the same work is also embodied in the organization charts of township offices, and there is an agricultural extension section at each district agricultural improvement station. Obviously, besides farmers' associations, the extension work can be handled by township offices as well as by district agricultural improvement stations. Therefore, under the 1970 plan to increase summer vegetable production, the following adjustment measures have been taken for the organization and training of vegetable farmers:

1. The extension workers of township farmers' associations are put under the supervision and guidance of technicians of the district agricultural improvement stations. Since vegetable cultural methods and pest control techniques have made great strides in recent years, it is beyond the grasp and ability of the township extension workers to effectively cope with the present various problems of extension. Under the plan the technical personnel of the agricultural improvement stations have undertaken to train township extension workers on the one hand, and to help them solve the various field problems on the other.

2. For training vegetable production team members, the township agricultural workers are to be invited by the local farmers' associations to attend both the discussion meetings to formulate training programs and the training classes to take part in the training of vegetable farmers, together with the technical personnel of agricultural improvement stations. Thus, administratively the organization of training can be made effective, and technically a sound training system is established.

3. Applications for production facilities on the part of vegetable farmers, such as the building of simple packing houses and small-scale irrigation systems, are subject to investigation, planning, supervision and final acceptance by the technical group of township offices before being used cooperatively by the vegetable farmers under the direction of extension workers of township farmers' associations. Thus, all the establishments can be endorsed by proper channels and used to the best advantage.

4. The main responsibilities of the extension workers of township farmers associations are to supervise integrated vegetable production practices, cooperative control of vegetable diseases and pests, and cooperative marketing of vegetable produce, thus paving the way for commercialization of vegetable production in the future.

REPORT ON THE IMPROVEMENT AND PRODUCTION OF MAJOR FIBER CROPS IN TAIWAN

Pa-Lun Chang

The major fiber crops referred to herein are of the long vegetable types including jute, kenaf, sisal and flax, which have been established for either domestic consumption or export. Although these crops occupy rather small acreages in Taiwan, yet they play vital roles in the national economy. This report deals with the progress in the improvement and production programs of the major fiber crops in the last decade.

I. Jute

Production

In the past jute was produced mainly for domestic consumption by the Taiwan Sugar Corporation and the Provincial Food Bureau as packaging material. But on account of the increased amount of sugar exported in bulk rather than in bags and the gradually reduced export of rice in recent years, the demand for jute has been on the decrease. Therefore, its annual production has been fluctuating to a certain extent. Table 1 shows the acreage, unit yield and production of jute in Taiwan since 1958 when the Joint Commission on Jute Extension and Procurement was established by the related agencies to develop jute production.

Table 1. Jute acreage and yield, 1958-1968

Year	Acreage (ha)	Retted fiber production (M.T.)	Retted fiber unit yield (kg/ha)	Year	Acreage (ha)	Retted fiber production (M.T.)	Retted fiber unit yield (kg/ha)
1958	12,644	17,096	1,352	1964	6,819	13,149	1,929
1959	17,864	24,013	1,344	1965	7,527	13,455	1,787
1960	16,278	20,806	1,278	1966	6,596	10,842	1,644
1961	11,051	13,772	1,246	1967	5,343	10,032	1,877
1962	7,734	10,794	1,396	1968	6,753	11,010	1,630
1963	6,696	9,930	1,483				

As shown in Table 1, much progress was made in the development of Taiwan's jute industry during the past ten years. Although the acreage of jute has dwindled year after year since 1962, the unit yield of retted jute was raised from 1,352 kg/ha in 1958 to 1,630 kg/ha in 1968. The phenomenal increase in per hectare yield of retted jute is due to the extension of pure seeds of improved jute varieties and better cultural practices. The following are some of the salient features of the jute improvement program in Taiwan in the past decade.

Improvement Program

A. *Varietal improvement*

Since 1953 when a set of standard procedures for jute breeding was established and put into effect, the Tainan Fiber Crops Experiment Station, PDAF has persistently tried to strengthen varietal improvement of jute. Under JCRR assistance, several new jute varieties were successfully developed through either selection or hybridization by the Station and have been extended to the farmers for commercial planting. The origin and characteristics of these new jute varieties are listed in Table 2.

Table 2. Origin and characteristics of four jute varieties developed in Taiwan

Variety	Origin or parentage	Year of denomination	Retted jute		Adaptable region	Resistance to anthracnose
			Per ha (kg)	Over CK (in %)		
Tainung No. 1	Pure line selection	1962	2,700	10	Central & southern Taiwan	Strong
Tainung No. 2	Taichung Pai Ying Chih × Early red	1966	2,900	13	Southern Taiwan	Fair
Tainung Selection No. 1	Introduced from India	1969	3,400	17	Central & southern Taiwan	Strong
Tainung No. 3	Huwei Green Bark No. 7 × Taichung Selection No. 1	1969	4,900*	21	Central Taiwan	Strong

* Scratched jute

B. *Multiplication and certification of jute seed*

In 1961, PDAF started the jute seed multiplication program with a new strain, Y-6-466, which was denominated as Tainung No. 1 in 1962. Since then, three levels of seed farms (foundation, stock and extension) were established by PDAF with the new varieties listed in Table 2, in cooperation with the Tainan FCES and the Taichung DAIS for multiplying seeds to be extended to jute farmers who were very much impressed with the certified seeds. Jute seeds with certified tags were usually sold at a price 20% higher than those without seed tags. This program was a great boost to raw jute production in Taiwan.

C. *Establishment of Fiber Testing Laboratory*

Fiber testing requires special apparatus and knowledge which most of the Asian countries lack. In 1961, through the recommendation of USDA, Mrs. Irene Doub, Physical Science Aide of the Everglade Experiment Station, Florida, was invited to come to Taiwan and advise us on the techniques of fiber testing. She taught 12 local technicians the principles and methods of fiber quality determination. Upon her recommendation, a fiber testing laboratory was built at the Tainan FCES with the necessary equipment for temperature and humidity control and a set of fiber testing instruments. This laboratory has been very helpful in the recent improvement of fiber quality in Taiwan.

D. Fiber quality improvement

In recent years, the retted jute in Taiwan has been inferior in tensile strength, resulting in low yarn and sack quality. To tackle this problem, JCRR rendered assistance to the Tainan FCES in strengthening studies on fiber-processing techniques. An investigation into the farmers' retting methods of jute uncovered many defects in the processing techniques, one of which was the over-retting operation which accounted for the poor tensile strength of fiber. Based on the findings, the grading and standards of retted jute fixed in 1949 for procurement inspection of fiber were revised at a discussion meeting sponsored by PDAF early 1968. This revised grading and standards have been in use since the 1968 crop season. Due to the change of grades and standards of retted jute, the farmers have been paying more attention to the operation of retting techniques.

According to an extensive survey of 18 townships made by the Tainan FCES in September 1968, the fiber-breaking load of jute increased from 19 lb/in^2 average in 1964-67 to 29 lb/in^2 in 1968. Although our fiber strength of jute has improved, it is still low when compared with that of the major jute-producing countries of the world where it has been raised about 50% in strength during a short period.

E. Development of jute decorticator

In order to lower labor cost of ribboning, a mechanical decorticator called "Type C" for jute ribboning was developed by the Tainan FCES in 1963 and subsequently extended to the farmers for commercial use. This machine is powered by a 5-7 HP diesel engine and can be easily moved from farm to farm during harvest. The work capacity of the decorticator is about 5,000 kg of green ribbons from 0.25-0.30 hectare of jute farm in an 8-hour day. Four to five laborers are required for the operation, with one operating the machine and the rest processing the fiber.

II. Kenaf

Production

Kenaf has many characteristics in common with jute with which it could be blended for making gunny sacks for packing sugar and rice. In view of its higher yield on land of lower grade, kenaf has become one of the important fiber crops in Taiwan for use as jute substitute. The acreage, yield and production of kenaf from 1960 to 1968 are listed in Table 3.

Table 3. Kenaf acreage and yield, 1960-1968

Year	Acreage (ha)	Retted fiber production (M.T.)	Kg retted fiber/ha	Year	Acreage (ha)	Retted fiber production (M.T.)	Kg retted fiber/ha
1960	8	4	534	1965	1,507	3,773	2,503
1961	143	266	1,844	1966	1,472	3,477	2,362
1962	120	164	1,372	1967	2,222	4,191	1,886
1963	2,524	4,496	1,781	1968	1,199	2,401	2,002
1964	1,393	3,349	2,404				

Improvement Program

A. Varietal improvement

In 1962, the introduced kenaf variety, BG-52-7, was officially denominated and released to farmers for commercial planting. Subsequent expansion of acreage with this variety was very rapid. However, it has unfortunately become susceptible to diseases and insect pests in the past two years, thus lowering both the yield and quality of retted fiber. This shows that a kenaf variety under natural conditions in Taiwan may degenerate in about eight years after its commercial planting. Under the circumstances, kenaf-breeding procedures in Taiwan should be improved and the time required for developing a new variety shortened to expedite breeding work to meet the need for renewing the old variety.

To replace the above-mentioned commercial variety, another new strain of kenaf, FS 55-3021-1, chosen by line selection method from one of the introductions was developed and the denomination of "Tainung No. 1 (kenaf)" was given to this strain in 1968. This newly released variety has been found resistant to anthracnose disease and leafhopper, and is capable of giving 15% higher yield than variety "BG-52-7". The task of seed multiplication of this variety is being undertaken by PDAF for future extension.

B. Blending test with retted kenaf for sack making

In the past, the Taiwan Sugar Corporation (TSC) had many times indicated its reluctance to extend the planting acreage of kenaf for the sole reason that some foreign countries had objected to the jute-and-kenaf-blended sacks used by TSC for packing sugar for export. According to them, the gunny sacks produced in Taiwan were inferior in quality due to the blending of kenaf fiber in the sacks. In order to clear up the problems existing in the extension of kenaf planting, a blending test with retted fibers from both jute and kenaf was conducted by PDAF with the help of JCRR during the summer months of 1966. In this test, a total of 121,230 kg retted fibers (91,500 kg of jute collected from 11 townships and 29,730 kg of kenaf from 3 townships) were used at four blending ratios. The Hsin-sheng Gunny Sack Mill at Hsinying, Tainan County was responsible for the spinning and weaving of the tested sacks; while the Tainan FCES and the TSC were responsible for quality testing of the fiber samples, yarn and sacks. From the test it was found that the blending ratio of jute 4 : kenaf 2 could be used successfully without appreciably affecting yarn and sack quality, despite the fact that the ratio of jute 3 : kenaf 3 has also shown fairly good results. All these findings have been agreed upon and accepted by the parties concerned. This proves that the policy on the extension of kenaf planting in Taiwan is right and worthy of further support.

III. Sisal

Production

Among the several kinds of fiber crops grown in Taiwan, sisal is an important item and ranks second only to jute so far as its planted acreage and economic value are concerned. In recent years, the total area planted to this perennial crop in Taiwan is around 10,000 hectares, of which more than 90 percent is in Hengchun, Manchow and Checheng townships on the southern tip of the island. Of the 9,500 tons produced annually, about 6,000 tons are for export with the remainder for making rope and fishing nets in Taiwan.

Improvement Program

For the purpose of promoting cultural improvement and fiber decorticating techniques of sisal crop, a sub-station of the Tainan FCES was established at Hengchun Township in 1963 under JCRR assistance. In 1966, JCRR helped PDAF in setting up a pilot sisal decorticating plant on the sisal farm of the Taiwan Agricultural & Industrial Enterprising Corporation. This plant is equipped with an automatic "Corona 2B" type decorticator purchased from England. Work progress of the plant has so far been quite satisfactory. Fiber percentage obtained reached 3.8% which is regarded as normal. Fiber quality has been greatly improved, because no more admixture was left on the washed sisal. Due to the successful trial running of the plant, eight more processing plants patterned after the one imported from England have been set up in the Hengchun area in the past two years.

IV. Flax

Production

The production of flax in Taiwan is mainly for export. In the past five years (1964-68), 2,000-3,000 ha of land planted to flax annually in central Taiwan gave a total yield of 1,700-2,000 M.T. Of the total, about 1,000 M.T. of line fiber were shipped to Japan each year as textile fabric and the rest of short fiber was consumed at home as raw material for the manufacture of cigarette paper. However, due to improper processing technique, the quality of cigarette paper made from the tow fiber is not good enough for cigarette making. Since no more short fiber is used in Taiwan at present, the local scutching mill has to sell this fiber to Japan at a low price. This is one of the problems confronting the flax industry.

Improvement Program

A. Varietal improvement

Up to the present, a total of 2,327 flax varieties have been introduced from foreign countries by the Tainan FCES for observation and trial planting. Among the introductions, C.I. 1799, 1769 and California 87903 have been found quite promising for fiber production. According to the experiments conducted in the past few years, these varieties consistently outyield the check variety, Taichung Selection No. 1.

The recent development of linseed industry in Taiwan has been given much attention. Some promising linseed varieties with high oil content and of superior quality have already been selected from field trials. However, production cost and utilization value of the short fiber scutched from the stalks of these varieties have to be thoroughly studied before taking steps to promote large-scale planting.

B. Improvement of cultural practices

1. Rate of sowing: The usual rate of sowing flax adopted by local farmers is about 70 kg per hectare. However, the results obtained from extensive tests in the past few years indicated that sowing at a heavy rate of 90 kg per hectare insures a thicker stand which gives higher yield and better quality. Based on these findings, recommendation has been made to the farmers for the improvement of flax cultivation.

2. Weed control: In Taiwan, weeds present a serious problem in the production of flax. From 1964 to 1966, tests with the herbicide, Karmex (Diuron), were carried out by the Tainan FCES, in cooperation with the Wujih Flax Scutching Mill in Taichung and Changhua areas, with satisfactory results. The application of Karmex at 500 grams per hectare shows excellent control of broad-leaved weeds without injury to flax. This new practice has been widely adopted by the flax growers in central Taiwan since its demonstration in 1967.

Future Efforts on Fiber Crops

Owing to the impact of synthetic fibers, the demand for natural fibers has been on the decline in recent years. Thus efforts should be made to explore the possibility of expanding the export of fiber and fiber products through better utilization. In the meantime, further improvement of fiber quality and lowering production cost of various fiber crops are important measures necessary for the development of fiber industry in Taiwan.

SUGGESTED MEASURES FOR IMPROVING TAIWAN'S SERICULTURE INDUSTRY*

Yung-Chun Lo

Historical Background

As early as 1661 or in the 15th year of Ming Emperor Yung Li, Cheng Cheng-kung, better known as Koxinga, introduced from mainland China the first batch of silkworm egg-sheets for hatching in south Taiwan. In 1885 (11th year of Ching Emperor Kuang Hsu), Liu Ming-chuan, the first governor of Taiwan, made elaborate plans to promote silk production among the mainland immigrants. A wealthy merchant named Lin Wei-yüan took up silkworm raising by planting mulberry trees in and around Taipei. Four years later, Li Lien-kuei, a silk producer in Yunlin, was officially sent to study sericulture technique on the mainland, thereby paving the way for sericulture in Taiwan.

During the 51 years of Japanese occupation from 1894 to 1945, the Japanese government despatched sericulture experts to Taiwan to rear silkworms and supplied mulberry seedlings and silkworm egg-sheets to Taiwan farmers. Meantime a sericulture training class was opened and trainees were subsidized with mulberry seedlings, fertilizers and egg-sheets. Then a silkworm-rearing station was built and Japanese industrialists were encouraged to establish filatures and egg-sheet production stations in appropriate areas in Taiwan.

In 1910, a mulberry seedling nursery was established, which was expanded to a sericulture institute (now the Taiwan Sericultural Improvement Station) three years later. Other measures for promoting sericulture were the publication of sericulture farming procedures and a system of reward for outstanding farmers. In 1915 a five-year plan to develop silkworm rearing in mountain areas was formulated to encourage farmers to take up sericulture, and ten years later a sericulture school was set up at Tahu in the Miaoli district. Since 1933 Japanese egg-sheet producers and sericultural experiment station personnel came to Taiwan to establish branch offices to engage in egg-sheet production for shipment to Japan. Then two silk-producing companies were formed in 1937 and 1938, respectively, to promote the rearing of camphor silkworms and castor silkworms.

As stated above, the early part of Japanese occupation was devoted to silkworm rearing and the latter part to egg-sheet production. According to a statistical study made by PDAF, the mulberry acreage in 1935 was 772 hectares; egg-sheets distributed among farmers in 1940, 12,813 sheets; total silkworms reared in 1937, 106,250 kg; raw silk produced in 1926, 14,138 kg, in addition to 254,000 egg-sheets shipped

* English version by Cheng Shu Pai.

to Japan. The lowest egg-sheet production was registered in 1944 when mulberry planting acreage was reduced to 217 hectares, egg-sheets numbered only 3,424, silkworm reared weighed only 22,769 kg, and raw silk produced was as low as 1,792 kg.

Since Taiwan's retrocession in 1945, the Taiwan Sericultural Institute was reorganized into the present Taiwan Sericultural Improvement Station by incorporating all the egg-sheet production units into a single body. Barely two years later, egg-sheets produced locally were in great demand by mainland filatures in Kiangsu and Chekiang, insomuch that the egg-sheet producers in the two provinces were attracted to Taiwan to undertake production on their own.

When the site of the Chinese Government was moved to Taiwan in 1949, the sericulture industry was vigorously promoted by the PDAF, the China Silk Company and the silk-producing plant of the Taiwan Industrial and Mining Corporation. A sericulture extension and experiment district was created at Tahu with JCRR financial assistance. In implementing a three-year sericulture promotion plan, JCRR assistance was also given to the Taiwan Sericultural Improvement Station for large-scale multiplication of mulberry seedlings, the construction of two incubation houses and 49 cooperative young silkworm rearing rooms, strengthening of silkworm rearing facilities and importation of superior egg-sheets from Japan.

Statistical Data on Sericulture Farming in Taiwan

Year	No. of growers	Planted mulberry acreage (ha)	No. of egg-sheets collected	Cocoon production (kg)	Av. no. of cocoon sheets (kg)	Raw silk produced (kg)
Prewar record		772 (1935)	12,813 (1940)	106,250 (1937)	10.8 (1936)	14,138 (1926)
Postwar record	5,485 (1956)	768 (1969)	27,531 (1956)	210,713 (1956)	11.6 (1963)	18,827 (1964)
1912		194	816	3,150	3.9	23
1922		187	5,564	40,687	7.3	3,195
1932		616	7,097	65,729	9.3	1,410
1942	710	239	8,938	69,512	7.8	4,890
1952	2,373	148	12,697	74,858	5.9	5,593
1962	3,003	384	12,188	134,861	11.1	12,682
1965	3,885	348	15,590	137,651	8.8	14,265
1966	2,621	433	15,906	161,306	10.1	15,001
1967	2,857	660	14,258	146,900	10.3	14,619
1968	2,744	819	14,172	144,117	10.2	14,684
1969	2,514	995	12,025	142,328	11.8	13,427
1970*			14,510	181,320	12.5	19,083

* Planned goal for 1970.

Not long afterwards, the sericulture sub-committee of PDAF was expanded into a sericulture assistance committee, as was the Sericulture School at Tahu which was converted into the Vocational Agricultural School run by the Miaoli County Government. The Taiwan Silk Company was founded in 1955 and the Tahu Filature by the Miaoli Farmers' Association. As a result of brisk demand for silk early 1960, two more filatures were established at Taitung and Lotung, respectively, followed by the fourth filature built by the Hsinchu Farmers' Association at Paoshan. Egg-sheets were distributed by the filatures as purchase of raw material as well as for extension of sericultural farming practice.

Through years of extension efforts, egg-sheet production in 1953 surpassed the record made during the period of Japanese occupation, and again in 1956 established an all-time high of 210,713 kg. In recent years when the demand for silk products soared on the international market, Taiwan began to produce its own silk material (fabric). It was in 1965 that silk production was formally included in the Government's four-year economic development plan to step up silk production for export.

Integrated Sericulture Demonstration Area at Paoshan—A Stepping Stone to Sericultural Development

This area is situated at the Shanhu village of Paoshan Township, about 10 kilometers from Hsinchu Municipality. Of the total area of 879 hectares, 360 ha or 41 per cent is cultivated land with two-crop and single-crop paddy fields which constitute 26 per cent; dryland fields, 74 per cent; while 519 ha or 59 per cent is forest land. Besides growing rice in the paddy field, tea, sweet potatoes, peanuts, banana, citrus and other fruit trees are planted on the dryland where both land and labor productivity is low.

A. Improvement measures taken

In the past sericulture industry in Taiwan was at a low ebb for the following reasons:

1. Sericulture farmers were widely scattered and unorganized, and their work piecemeal, characterized by low productivity. As the filatures had to shoulder the expenses of sericultural extension, the price of cocoons paid to the farmers was low, thus accounting for the lack of interest on the part of farmers.

2. Because of the low returns from rearing silkworms, the farmers were reluctant to make additional investment and put in extra effort to adopt improvement measures. To promote sericultural productivity and, in turn, raise the farmers' income, the Taiwan Sericultural Improvement Station in 1966 mapped out a series of improvement plans including a) encouraging integrated mulberry planting by organizing sericulture farmers, strengthening technical guidance, upgrading farm management and raising egg-sheet production and quality; and b) streamlining the cocoon-purchasing system by offering reasonable prices as a measure of stimulating the farmers' interest in sericulture.

All these measures, under the financial assistance of JCRR and supervision of PDAF, were duly executed by the

Taiwan Sericultural Improvement Station in cooperation with the county governments, farmers' associations and the Miaoli Filature of the Taiwan Silk Company. Training classes were organized for the 40 farmer families who volunteered to take part in the integrated demonstration of sericultural techniques. A group leader and three class leaders were chosen from among the farmers to be responsible for liaison work and extension activities. The improvement measures conducted for three years from 1967 to 1969 embodied the following objectives: 1) creation of basic sericulture families; 2) planting of more mulberry trees; 3) cooperative incubation of egg-sheets; 4) cooperative rearing of young silkworms; 5) establishment of mulberry farms, particularly for young silkworms; 6) construction of young silkworm cooperative rearing rooms; 7) modernization of silkworm rearing facilities; 8) overhaul of the cocoon purchasing system; 9) supervision over the management of mulberry farms; and 10) dissemination of sericultural techniques.

B. Accomplishments

1. A total of 40 basic sericulture farmer families were created.

2. An aggregate acreage of 21.06 hectares were planted to 109,745 mulberry seedlings, 66 per cent of which survived.

3. Seven mulberry farms for rearing young silkworms were established on two hectares of slopeland on which 12,000 mulberry seedlings were planted to supply leaves for 246 egg-sheets of young silkworms.

4. Three cooperative young silkworm rearing rooms were built.

5. Four simple silkworm rearing rooms were built with funds raised by the sericulture farmers themselves.

6. The system of fixing cocoon price according to the local silk price and cocoon quality was adopted, resulting in much higher price (61.04% more for spring crop and 52.62% more for fall crop) of cocoons sold by farmers in the demonstration area than that obtained by the other farmers.

7. Unit labor productivity was considerably raised by supervising the farmers to rear adult silkworms on mulberry branches and adopting effective pest control methods.

C. Work performance in the sericultural demonstration area in 1969

1. In the demonstration area the average size of each family was 8.1 persons with 3.4% of them (male 1.6, female 1.8) engaged in sericulture. The average farm size of each family was 2.47 ha, consisting of 0.39 ha paddy field, 0.73 ha dryland, 0.63 ha orchards, 0.53 ha mulberry farms and 0.2 ha forest land. The largest mulberry farm was 1.55 ha and the smallest 0.1 ha, on which trees of 2-3 years were grown.

2. On the 21.06 ha of mulberry farms, the average number of trees planted by each family was 5,211 with the maximum and minimum number of trees planted by each family 6,550 and 458, respectively. The total number of egg-sheets produced for the whole year was 246, averaging 6.2 sheets per family (max. 22, min. 2). The maximum and minimum number of egg-sheets produced

each time was 5 and 0.5 respectively, while the total sheets produced from each hectare of mulberry farm numbered 11.7 (max. 30, min. 5.6).

3. Of the 5,123 kg of cocoons reared in 1969, 36.81% was produced in spring; 8.24% in late spring; 11.91% in summer; 21.7% in fall; and 21.26% in late fall. The average cocoon production in each family amounted to 128 kg (max. 603 kg, min. 36 kg). Cocoon raised from each hectare of mulberry farm weighed 243 kg (max. 629 kg, min. 84 kg). The cocoons hatched from each egg-sheet weighed 20.83 kg.

4. The total agricultural production of 40 families was valued at NT$1,187,942, averaging NT$29,629 per family. The value of sericultural production was NT$383,693, averaging NT$9,548 per family, or 32.3% of the total agricultural production. The highest income earned by a single family was NT$44,514 and the lowest NT$2,627. The remaining production value of NT$804,249 (NT$20,106 per family) occupied 67.7% of the total agricultural production (max. income per family NT$45,000, min. NT$3,600).

5. The total cost of sericultural production amounted to NT$486,913, of which labor occupied 73.3%, material 5%, fertilizers 3.9%, egg-sheets 1.9%. The cost of producing each kilogram of cocoons averaged NT$87.54.

Percentages of cost of production in the sericulture demonstration area compared with those in Japan are shown below:

	Demonstration area	Japan
Cost of egg-sheets	1.9	6.9
Cooperative rearing	1.6	2.7
Fertilizer	3.9	9.7
Material	5.0	4.8
Pest control	1.8	0.5
Farm erection	2.9	4.8
Building	9.6	4.0
Farm tool		5.5
Labor	73.3	61.1
Total	100	100

Recommended Courses To Be Taken and Key Points for the Improvement of Sericulture Farming in Taiwan

A. Saving of labor:

At present the proportion of labor required for silkworm rearing and mulberry planting is four to one. Only through improvement of sericultural techniques can labor be saved to a large extent. Measures for lowering labor cost and increasing sericultural production are: using oiled paper to prevent shredded mulberry leaves from drying too soon when rearing young silkworms, rearing adult silkworms on mulberry branches, designing simple adult silkworm rearing rooms, adopting successive silkworm rearing technique and basic labor-saving pest control methods, and making use of other time-saving devices.

As to mulberry planting, research on proper soil and fertilization and on ways and means to raise land productivity and adopt basic improved mulberry planting techniques should be strengthened. Furthermore, the introduction of adaptable farm machinery is also necessary, as well as devising the organization of highly efficient productive mulberry farms suitable for mechanization and successive silkworm rearing.

B. Lowering of the cost of cocoon production

At present the cost of cocoon production still accounts for the lion's share of labor expenses, thereby highlighting the need for adopting time-saving devices to economize on time spent in silkworm rearing. One of the major causes of unstable cocoon production has been the incidences of pests and diseases, such as silkworm jaundice, flacherie, mascardine, long horn beetle, scale and plant lice, which must be effectively controlled through strengthened research before unit cocoon production can be substantially raised.

C. Integrated application of sericultural techniques

At a time when land use has become more sophisticated and competition among crops of high economic value is getting more acute, the sericulture industry can only be developed through large-scale operation of sericulture farms, mechanization and simplification of production processes. Henceforth, regardless of whether the sericulture farms are operated individually or cooperatively, the farmers must try to improve operations by resorting to integrated production practice.

D. More income to sericulture farmers

It is believed that the farmers' income can be greatly increased if the silkworm-rearing farms are localized and the rearing capacities enhanced. Meantime, an efficient cocoon purchasing system whereby the cocoon price is based on both the local price of silk and the result of cocoon-quality testing should be enforced in order to maintain a reasonable price satisfactory to all.

E. Improvement of silkworm species to increase productivity

Both the quantity of cocoons produced and the quality of raw silk can be raised if improved varieties of silkworms and mulberry are introduced.

In conclusion, I wish to make a comparison of efficiency in sericulture farm management between our sericultural demonstration area and Japan as a whole in order to stimulate our sericultural workers to greater efforts:

	Demonstration area	Japan
Av. size of each mulberry farm (ha)	0.53[1)]	0.34[2)]
Av. cocoon production of each farm (kg)	128	240
Av. cocoon production of each hectare (kg)	243	712
Av. cocoon production of each egg-sheet (kg)	20.8	22.1
Labor returns for each family (NT$/day)	34	175

1) Trees of two and three years old.
2) Mature trees.

GREEN MANURES

Chun-Muh Wong

Definition

A crop which is plowed down in its green state for manuring purpose is called green manure. In the livestock-raising countries green manure crops are commonly included in the crop rotation system for feeding the animals. In Taiwan, farmers generally utilize fallow land to grow green manures, and use a part of it for green roughage whenever necessary. The planted acreage, production and consumption of green manures as reported in the Taiwan Agricultural Yearbook are shown in Table 1. The consumption here includes those crops which are not originally intended for green manuring but are plowed down by farmers due to crop failure or other economic factors.

Advantages and Disadvantages of Green Manures

The following are the advantages of growing green manures:

1. Supplementing soil nutrients or increasing the availability of nutrients to plants;
2. Control of weeds and reduction of soil erosion;
3. Improvement of soil tilth;
4. Regulation of soil temperature to benefit interplanted crops;
5. Improvement of the physical properties of sub-soil and increase of plow layer depth.

The few disadvantages of growing green manure crops are:

1. The cost of N from green manures is higher than that of chemical fertilizers;
2. They induce more disease, pest and nematodes damage;
3. They compete with interplanted crops for soil moisture in the dry season;
4. Many legumes grow too slowly at early stage and may interfere with the proper planting season of subsequent crops if the farmers want to get the most out of green manures.

Fertilizing Value of Green Manures

Many experiments have been conducted on rice, sugarcane, tea and pineapple in the past to compare yield responses to NPK in green manures versus those of chemical fertilizers. For rice, the effect of Chinese milk vetch (*Astragalus sinicus*) on coarse-textured soils is higher than on fine-textured soils. There is no significant difference between green manure and chemical fertilizers in general, but on poorly-drained soils, green manure has an adverse effect on rice yield.

For sugarcane, sunn hemp (*Crotalaria juncea*) can substitute a part of N-fertilizer for basal application. Its effect on cane yield in the first harvest is only 53% as compared with chemical fertilizers, but in the consecutive harvest, the cumulative effectiveness of green manure increases to 70% of chemical fertilizer treatment.

For tea, long-term experiments reveal that lupine is inferior to chemical fertilizers. Continuous application of lupine for eight years produces tea yield only equal to 74-82% of chemical fertilizers.

For pineapple, growing velvet bean (*Mucuna capitata*) before planting does not make any difference if an adequate amount of chemical fertilizers is applied on the pineapple crop.

Changes of Type and Acreage of Green Manures

Green manures can be classified into two groups: leguminous and non-leguminous. The chief features of legumes are to produce nodules capable of fixing free nitrogen, and their leaves and stems are tender and decomposable. Also, the fresh yield of legumes is high, with comparatively low C/N ratio, and can substitute for a part of N fertilizer. However, it does not help much in supplying organic matter to the soil, except in the case of perennial cover crops. The non-leguminous green manures, mostly grasses, are adaptable to varying environmental conditions, and their growth at the early stage is faster than that of legumes. When turned under, more organic matter is produced to improve the soil.

In Taiwan, green manures are commonly referred to as legumes. During the interval between the first and second rice crops only *sesbania aculeata* is grown in the south. It is during the long winter season that growing of green manures increases in number. The growing of black beans, green soybeans, *sesbania*, etc., in paddy fields was once quite common in the south, but they are now replaced by such field crops as soybean and kidney bean. In the central and northern part of Taiwan, Chinese milk vetch, green soybean, green pea, black bean, rapeseed and radish (*Raphanus sativa*) can be grown. In the upland area, the spring- and summer-planted legume crops are *sesbania*, velvet bean, *crotalaria*, *vigna*, Okinawa soybean, etc. Fall- and winter-planted ones are *sesbania*, *vigna*, lupine, green soybean, etc.

The peak record of green manure acreage was 237,892 ha in 1942. After World War II, the highest record of 216,420 ha was made in 1949. Since then the acreage has been decreasing, particularly for those planted in the paddy field. In 1967 the planted area of 74,000 ha was only one-third that of 1949. In the summer of 1968, JCRR subsidized the Provincial Department of Agriculture and Forestry to make a spot-check covering the main producing townships in the south. It was discovered that the actual acreage was even less than that reported in the previous year. It is, therefore, suspected that the planted acreage given in the 1968 yearbook (64,079 ha) might still have been over-estimated.

The main reasons for the decrease of green manure acreage are summarized as follows:

1. The increase in demand for chemical fertilizers is brought about by the lowering of their prices. On the other hand, green manure is no better

than chemical fertilizers.

2. Advancement of plant protection and cultural practice techniques coupled with the development of water sources makes it possible for more crops to grow in Taiwan thus making the growing of green manure uneconomical.

3. The price of green manure seeds is on the increase owing to high labor cost.

Present Problems and Future Outlook

Owing to the fact that arable land in Taiwan is limited and the population is steadily increasing, it is our government policy to continue to stress "food production"; and the green manures planted in the plain area will eventually be replaced by crops of higher economic value with the application of chemical fertilizers. This phenomenon is considered normal and a sign of agricultural progress. However, in some places, the growing of green manures is still important and necessary, therefore it should also be encouraged. The future plans for green manure development are suggested as follows:

1. For aboriginal townships: The poor aboriginal farmers use extensive farming practices. The long winter fallow period is suitable for growing green manures. It is advisable to introduce and extend in these areas green manures which are easy to grow and the seeds of which are easy to collect for home use as well as for sale.

2. For slopeland: The erosion problem is fast becoming serious as more slopeland is developed for growing fruit and other crops. Perennial green manures should be interplanted to check soil erosion. They are also good for mulching to control weeds and improve soil fertility.

3. For livestock enterprises: Many green manures are good forage crops. In areas where livestock projects are underway, suitable green manures can be introduced as feedstuff.

4. For research: Table 2 shows a total of NT$5.3 million which was provided by JCRR, for the respective green manure and cover crops programs during the past 20 years (FY1950-69). As the conditions change, it is suggested that the research work should lay stress on the study of the effect of green manuring on the change of soil properties and soil moisture in the field with the perennial crops.

Table 1. Acreage and production of green manures

Year	Acreage (ha)	Production (M.T.)	Consumption (M.T.)
1949	216,420	2,913,309	2,929,399
1950	198,621	2,078,557	2,078,557
1951	202,950	1,837,926	1,837,926
1952	207,103	1,880,745	1,878,247
1953	192,269	1,862,490	1,862,490
1954	173,633	1,617,487	1,627,340
1955	161,758	1,489,616	1,489,616
1956	166,550	1,543,565	1,544,921
1957	139,760	1,287,047	1,275,607
1958	137,283	1,229,026	1,223,802
1959	132,136	1,229,060	1,227,755
1960	121,644	1,125,447	1,164,755
1961	109,101	1,023,522	1,107,322
1962	114,718	1,111,082	1,112,825
1963	102,254	984,856	998,604
1964	91,234	918,641	927,792
1965	79,528	800,186	813,748
1966	76,897	771,832	773,616
1967	74,247	780,668	782,222
1968	64,079	654,283	665,510

	1949	1965
Paddy	196,248 ha	68,922 ha
Dryland	20,172	10,606
Total:	216,420 ha	79,528 ha

Source: Taiwan Agricultural Yearbooks, PDAF (1968)

Table 2. Green mannure projects financed by JCRR since 1950

Unit: NT$

FY	Rice				Tea (Lupine)		Pineapple/banana		Cover crops		Total budget
	Astragalus		Others								
	Project code	Budget	Project code	Budget	Project code	Budget	Project code	Budget	Project code	Budget	
1950		—	—11	18,000 (TARI)	—39b	90,000 (TPBAF)		—		—	
		—	—39a	50,000 (TPBAF)				—		—	158,000
1951		—	—94	28,700 (TARI)	—98	60,000 (PDAF)	—126	4,609 (TVFMC)		—	93,309
1952		—	—197	5,960 (NBAR)	—243	90,000 (PDAF)	—209	7,755 (TPC)		—	
		—		—		—	—214	13,450 (TVFMC)		—	117,165
1953		—	—285	31,800 (NBAR)	—351	156,500 (PDAF)	—302	25,920 (TPC)		—	
		—		—		—	—303	24,000 (TVFMC)		—	238,220
1954		—		—	—451a	81,600 (PDAF)	—394a	31,350 (TVFMC)	—371a	14,000 (TFRI)	
		—		—		—	—394b	59,440 (TPC)	—371b	54,500 (TARI)	
		—		—		—		—	—419	16,150 (TARI)	257,040
1955	—468	13,500 (TARI)		—		—	—486a	10,000 (PDAF)	—467	69,500 (TARI)	
		—		—		—	—486b	25,950 (TPC)		—	118,950
1956	—540	68,400 (TARI)	—549	15,299 (TY H.Gt)		—		—	—562	79,260 (TARI)	162,959
1957	—620	66,500 (TARI)		—		—		—		—	
	—686	178,500 (PDAF)		—		—		—		—	245,000
	〃	300,000 (〃 Loan)		—		—		—		—	300,000(L)
1958	—695	35,280 (TARI)		—	—720	15,950 (PTES)		—	—759	36,500 (TARI)	87,730
1959	—805	308,000 (PDAF)		—	—803	48,000 (PTES)		—	—860	40,980 (TARI)	396,980
1960	—917	370,000 (PDAF)		—	—916	86,600 (PTES)		—	—985	111,400 (TARI)	568,000
1961	—1087	258,200 (PDAF)		—	—1097	57,000 (PTES)		—	—1131	38,000 (PDAF)	
	〃	59,800 (TARI)		—		—		—	—1148a	215,500 (PDAF)	
		—		—		—		—	—1148b	50,700 (TARI)	679,200
1962	—1258	102,000 (PDAF)		—		—		—	—1338	440,000 (PDAF)[1]	
		—		—		—		—	—1355	111,000 (TARI)	653,000

Table 2. Green mannure projects financed by JCRR since 1950 (*Continued*)

Unit: NT$

FY	Rice				Tea (Lupine)		Pineapple/banana		Cover crops		Total budget
	Astragalus		Others								
	Project code	Budget	Project code	Budget	Project code	Budget	Project code	Budget	Project code	Budget	
1963	−1435	105,000 (PDAF)	−1390	26,000 (TC DAIS)		—		—	−1565	86,700 (PDAF)[1]	
		—		—		—		—	〃	53,400 (TARI)	271,100
1964		—		—		—		—	−1620	100,000 (PDAF)[1]	
		—		—		—		—	〃	103,000 (TARI)	203,000
1965		—		—		—		—	−1663	105,000 (PDAF)[1]	
		—		—		—		—	〃	85,000 (TARI)	190,000
1966		—		—		—		—	−1725	56,000 (PDAF)[1]	
		—		—		—		—	〃	126,000 (TARI)	182,000
1967		—		—		—		—	−1804	65,000 (PDAF)[1]	
		—		—		—		—	〃	85,000 (TARI)	150,000
1968		—		—		—		—	−1869	68,000 (PDAF)[1]	
		—		—		—		—	〃	82,000 (TARI)	150,000
1969		—		—		—		—	−1937	44,000 (PDAF)[1]	
		—		—		—		—	〃	82,000 (TARI)	126,000
TOTAL	NT$1,565,180 NT$300,000 (Loan)		NT$175,759		NT$685,650		NT$202,474		NT$2,418,590		NT$5,047,653 NT$300,000 (L)

[1] Excluding PDAF's contributions:

1962	−1338	NT$ 30,000
1963	−1565	60,000
1964	−1620	100,000
1965	−1663	100,000
1966	−1725	100,000
1967	−1804	80,000
1968	−1869	60,000
1969	−1937	40,000
Total:		NT$570,000

Remarks: TARI—Taiwan Agricultural Research Institute; TPBAF—Taiwan Provincial Bureau of Agric. & Forestry; PDAF—Provincial Department of Agriculture & Forestry; TVFMC—Taichung Vegetable & Fruit Marketing Cooperative; NBAR—National Bureau of Agricultural Research; TPC—Taiwan Pineapple Corporation; TFRI—Taiwan Forestry Research Institute; TY H.Gt—Taoyuan Hsien Government; PTES—Pingchen Tea Experiment Station; TC DAIS—Taichung District Agricultural Improvement Station

SOIL TEST AND STUDIES OF ITS APPLICATION IN TAIWAN

Nan-Rong Su

The fertility state of soil is one of the important factors that affects the nutrient requirements of crops. Therefore, tests of soil nutrient levels and other soil properties related to the release and availability of nutrients are of great value to fertility management of agricultural land. However, interpretation of soil test results, in terms of the degree of nutrient deficiency and fertilizer requirement, is not possible unless extensive field fertilizer trials are carried out to calibrate, or evaluate, the test values. Work on soil test thus involves both the test itself and its interpretation and application.

Survey of Soil Fertility

In the early 1940's overall fertility of cultivated land in Taiwan was surveyed by the Japanese soil scientists. The items tested were texture, organic matter, total N and hot-hydrochloric-acid-soluble calcium, magnesium, potassium and phosphorus. The soil fertility surveys conducted after World War II are described below.

A. *General fertility survey of arable land in 1949-1961 by TARI*

More than 600,000 ha of cultivated land were covered in this survey. A total of over 2,000 soil samples were tested including both surface soil and subsoil. Each surface or subsoil sample represented 600 ha. Items analyzed were: texture, pH, organic matter, total N, available P and K by Peech's method. The results were compiled by S. C. Chang in 1951 into a report entitled "A General Study on Soil Fertility of Taiwan" which included maps of the items surveyed.

B. *Detailed fertility survey of arable land in 1959-1967 by TARI*

This work was carried out successively by H. D. Tseng, C. H. Wang and C. F. Lin. The number of samples was 78,635, covering 790,000 ha of agricultural land in 15 counties; each sample represented 10 ha. The items analyzed were texture, pH, organic matter by the modified Walkley-Black method, available P by Bray's No. 1 method and available K by Mehlich's method. Each of the five tested items was mapped on the 1:100,000 scale for each county and on the 1:500,000 scale for the whole island of Taiwan. These maps were published in color in 1967 together with a survey report (A Report on the Soil Test for the Cropland of Taiwan, Bulletin of Taiwan Agricultural Research Institute No. 28). This survey did not include the small acreage occupied by Penghu County, Taipei Municipality and five provincial cities.

The results are summarized as follows:

1) Texture:

The lighter-textured soil is most

abundant in Miaoli and Yunlin Counties, followed by Hsinchu County. Medium textured soil predominates in Ilan and Taichung Counties, followed by Changhua, Tainan, Chiayi, Taitung, Kaohsiung and Pingtung Counties. The finer textured soil is abundant in Taoyuan County, followed by Nantou and Taipei Counties. The overall distribution of soil in individual textural classes is shown below:

Textural class	% Distribution
Sand and loamy sand (coarse)	1
Sandy loam (medium coarse)	36
Loam, silt and silt loam (medium)	44
Sandy clay loam, silty clay loam and clay loam (medium fine)	19
Sandy clay, silty clay and clay (fine)	0.04

2) Soil reaction:

Soil in the northern areas (Taipei, Taoyuan, Hsinchu) is strongly acid. Soil acidity is generally strong to medium in Nantou, Miaoli and Ilan, medium to strong in Taichung and Taitung. From Changhua County down south and in Hualien, the soil is much less acid on the average and, moreover, a great proportion of the soil in Changhua, Yunlin and Tainan is in the alkaline range.

Soil pH	% Distribution
Below 5.6 (strongly acid)	33
5.6-6.5 (moderately acid)	25
6.6-7.3 (neutral)	16
7.4-8.0 (slightly alkaline)	22
Above 8.0 (alkaline)	3

3) Organic matter:

The soil in Tainan, Chiayi and Yunlin Counties is most deficient in organic matter, followed by Nantou, Miaoli, Kaohsiung and Hsinchu. That in Taoyuan, Taipei and Taitung County is relatively high in organic matter; others intermediate.

Soil organic matter (%)	% Distribution
0-1	14
1-2	51
2-3	27
Above 3	8

4) Available phosphorus:

Generally speaking, the soil in Taichung County is the most abundant in available phosphorus, while that in Taoyuan County is the most deficient. Soil in the other areas contains intermediate amounts of phosphorus.

Available P (ppm)	Available P_2O_5 (kg/ha)	% Distribution
0-4	0- 23 (very low)	7
4-10	24- 58 (low)	30
10-20	59-115 (medium)	32
Above 20	Above 115 (high)	31

Based on past trials, rice will generally respond to application of phosphate fertilizer where available phosphorus is medium or lower. Thus, about 70% of the cultivated soil in Taiwan is P-deficient and requires application of phosphate. It is estimated that the phosphate effect will be particularly significant in about 40% of the cultivated land, i.e., in soil containing low or very low amounts of available phosphorus.

5) Available potassium:

Ilan and Changhua Counties rank the lowest in soil available potassium content, followed by Hualien, Pingtung, Taitung, Taipei and Taoyuan. The soil in Miaoli and Hsinchu has the highest soil K level, followed by Taichung. Other areas are intermediate in K status.

Available K (ppm)	Available K_2O (kg/ha)	% Distribution
0-15	0- 45 (very low)	4
15-35	46-105 (low)	37
35-80	106-240 (medium)	43
Above 80	Above 250 (high)	16

In about 40% of the soil containing very low to low amount of available K, rice will probably respond significantly to the application of potash fertilizer. Half of the soil containing medium level of K may also respond to potash application to some extent. Therefore, it is estimated that slightly less than 2/3 of the cultivated soil in Taiwan is deficient in K with regard to rice.

C. *Detailed fertility survey of Penghu soil in 1969 by TARI*

The area surveyed is 8,540 ha, which is larger than the registered cultivated land. Frequency of soil sampling, items of analysis and the scale of soil fertility maps prepared are the same as stated in B.

Texture: Mostly coarse to medium coarse in textures (sand and loamy sand 51%; sandy loam 35%)

Reaction: Mostly alkaline (46% with pH of 7.4-8.0; 49% with pH above 8.0)

Organic matter: 74% of the soil contains less than 2% organic matter

Available P (Bray No. 1 method): 89% is low to very low in P: 36% very low (less than 4 ppm P) and 53% low (4-10 ppm p)

Available K (Mehlich's method): Mostly low to medium, i.e., between 15-80 ppm K (76%); 62% is low to very low in K: 17% very low (below 15 ppm K) and 45% low (15-35 ppm K)

D. *Survey of the state of some particular nutrients in soil*

1) Survey of soluble boron in Taiwan soil in 1959 by Taiwan Sugar Experiment Station:

Soluble boron contents of 336 samples were analyzed by T. C. Yang. The soil samples were grouped into three classes according to their boron status, i.e., less than 0.1 ppm B, 0.1-0.2 ppm B and above 0.2 ppm B. Schist and limestone alluvial soil samples and acid soil samples were generally low in soluble boron content. Percentages of soil samples containing less than 0.1 ppm B in individual soil groups were:

Schist and limestone alluvial soil	62%
Latosols	54%
Slate alluvial soil	43%
Sandstone alluvial soil	36%
Mudstone alluvial & saline alluvial soil	3-5%

2) Survey of available silica in sugarcane soil samples of West Taiwan in 1961 by Taiwan Sugar Experiment Station:

Soil samples from 74 sugarcane farms were analyzed for silica by J. J. Hsiue. Good correlation was found between silica content of cane plant and the acetate-buffer-extractable silica of the soil. Moreover, cane yields are correlated with silica status of the soil.

Coarse-textured alluvial soil samples are the lowest in available silica, while the salt alluvial soil samples are the highest. In the fine-textured alluvial soil samples and latosols, available silica is in medium amounts. The lower the pH, the lower the available silica content. Soil samples with pH values below 6.5 contain less than 100 ppm Si.

Study on the Application of Soil Tests

The soil tests alone are of little value unless studies are made as to how to interpret the test results in terms of the degree of nutrient deficiency or in terms of the amount of nutrient required for normal production. Such studies are made by calibrating soil test values with the results of the numerous simultaneously conducted field fertilizer experiments. This work may be called soil test calibration or soil test evaluation. It is a study on how to apply soil test in actual fertility management.

A. *Procedure of soil test calibration*

1) Selection of proper test methed:

There are a number of methods proposed for chemically testing soil nutrients. They give different test values for the same soil by virtue of differences in the strength of extraction as well as in the forms of nutrients extracted. A method that gives test values intimately correlated either positively with the amount of plant absorption or negatively with the degree of yield response to applied fertilizer must be selected. Thus, a large number of field fertilizer trials have to be carried out under widely variable conditions parallel with soil tests by various methods. Greenhouse trials may or may not be conducted first for preliminary information.

2) Evaluation of critical nutrient concentrations in soil:

The percentage yield increases obtained by the application of a given nutrient (or, alternatively, the percentage yields obtainable without its application) are plotted against corresponding test values of that nutrient in the soil samples, using the test values obtained by the test method selected in the way mentioned previously. Then a regression equation is calculated and a curve or line drawn. The critical concentration is that value of soil nutrient below which, according to the trend of the regression, yield increase may be obtained by the application of that nutrient. This is the boundary line between sufficiency and deficiency. Usually 98% yield without application of the nutrient (or alternatively 2% yield increase with its application) is taken as a criterion for setting the critical concentration. This standard may vary slightly according to personal opinion in consideration of the economy of fertilizer application. For best production, the nutrient level should be maintained above the critical concentration.

3) Grading of soil test values and estimation of economic nutrient rates for individual grades:

The soil test values, from zero up to the critical concentration, are classified into three to four grades, e.g., "very low", "low" and "medium". Values above the critical concentration may be graded as "high". Naturally, application of only a little or no fertilizer is recommended for soil which tests "high".

The amount of a nutrient required by the soil samples which test "very low", "low" and "medium" in that nutrient is estimated from the results of field trials. Knowing only the maximum amount (i.e., that which is required by the "very low" soil) and the minimum amount (i.e., the amount for "high" soil which may be zero to, say, 1/4 of the maximum), one can also intrapolate to know the amounts required in the intermediate soil test grades.

By using the field data it is also possible to obtain a compound equation which shows the yield level as the function of soil nutrient and applied nutrient. In this case, the rate of nutrient to be applied can be calculated by knowing the soil test value and the planned yield. For instance, the equation for potash obtained in the author's work on pineapple is:

$$\text{Log}(100\text{-}y) = \text{Log}100 - 0.00785(77+k) - 0.00132K$$

where y is the percentage yield (the yield in per cent of the maximum possible yield under environmental conditions) obtainable when the soil K content is k ppm and the fertilizer K_2O applied is K kg/ha.

B. Soil test calibrations in Taiwan

The earliest soil test calibration study in Taiwan was conducted in 1952 on sugarcane soil samples by T. T. Chao of the Taiwan Sugar Experiment Station. In 1958 a similar study was carried out on pineapple soil samples by the Touliu Pineapple Experiment Station. Then a series of soil test calibration studies were made by various institutions successively from 1960 up to now, on rice, sugarcane, tobacco, sweet potato, wheat, tea, corn and sorghum. The work mainly concentrated on two nutrients, phosphorus and potassium. Some studies were not successful due to inadequate management of the field trials. The method of compilation and interpretation of data needs refining in many of the studies. The results obtained in Taiwan are tabulated in the Summary Table of Relatively Successful Soil Test Calibration Studies in Taiwan. Only those studies, in which significant correlation was obtained between soil nutrient and yield response to added nutrient, are listed.

Limitations Encountered in the Study and Application of Soil Test

The nutrient state of soil is only one of the major factors deciding fertilizer requirement of crops. Other factors can significantly interfere with the effect of applied fertilizers and shift their optimal rates. The following are examples of such interferences observed in Taiwan.

A. Variety

The effect of siliceous fertilizer on some rice varieties, e.g., Hsinchu 56, Taichung 65 and Taichung Sen No. 2, is significantly greater than on other rice varieties, e.g., Tainan No. 5 and Aichaochien.

B. Climate

The effect of added phosphate and potash on rice is greater in a cold year than in a warm year. The effect of potash on pineapple is marked in the year of frost damage on the soil which contains a high level of exchangeable potassium and would not normally show any response to applied potash fertilizer. Response of corn to applied phosphate is more manifest when corn is sown late in the year than when sown earlier.

C. Type of soil

For the same soil available potassium level, the yield response of rice to applied potash is generally the highest in the case of latosols, medium in the case of sandstone-shale alluvial soil and the lowest in the case of slate alluvial soil. No difference in the magnitude of response was observed between the different subgroups of the latosols, i.e., the reddish brown and the yellowish brown latosols.

D. Physical properties of soil

The optimum rate of potash fertilizer for rice is higher in the ill-drained soil than in normal soil. Similarly, for the same state of K soil, the potash requirement of pineapple is larger in compact soil, but smaller in the newly cultivated permeable soil.

Further, the optimum rate of potash for pineapple for a given soil K value is lower in the case of light-textured soil than in the case of heavy textured soil. The situation seems to be reversed in the case of corn.

E. Cultural management

In a soil not so deficient in phosphorus, the effect of phosphate on rice becomes manifest when water shortage occurs. If the planting bed is prepared while the soil is still wet, the bed would become rather compact and the response of sweet potato to applied potash is higher than expected from the soil test value. Mulching practice will lower the requirement of pineapple for potash. The nutrient content of irrigation water affects the nutrient state of paddy field during the growth stage and changes the nutrient requirement of rice.

The yield level, which is the aggregate result of management and soil productivity, positively affects the percentage increase of soybean yield due to application of potash.

F. Plant density

The response of sweet potato to increased application of NK fertilizers is greater when plant density is low. The response becomes less as the plant density increases, until at the density of 37,600 plants per ha (0.8m × 0.33m) the yield increase is so little that only the lighter rate of application is justified.

In pineapple, it has been observed that the optimum rate of fertilizer is higher for the denser spacing system than for the wider spacing system.

G. Other nutrients

For a given soil K level, the optimum rate of potash for rapeseeds is proved to be higher with adequate nitrogen supply than with insufficient nitrogen application.

The ratio of exchangeable Mg to K in soil has a definite influence on the critical concentration of exchangeable K for pineapple growing. When the Mg/K ratio is high, the response of pineapple to added potash becomes low.

Unless the above-mentioned and other possible interfering factors are taken into consideration in addition to the soil test values, it is difficult to correctly interpret and make use of the soil test in actual fertilizer recommendation.

It should be noted that interferences of artificial cultural conditions are so strong that mere observations of soil properties and climatic factors often fail to provide satisfactory interpretation.

Some Opinions Pertaining to Further Development of Work in Soil Test

Attention should be paid to the following problems in utilizing the soil test and in the further development of soil test research.

1). The newest soil fertility maps available are based on the test results obtained in 1960-67. There must have been significant changes during the years since. Though these maps are still regarded as the best reference material for knowing the relative state of soil fertility, fertilizer application must be based on actual sampling and testing of individual soil samples in question.

2) In the detailed fertility survey, the unit of soil sampling was 10 ha, while the plot sizes in Taiwan are very much smaller, thus necessitating tremendous variations in soil fertility within the original sampling unit because of management diversity among individual farmers. Therefore, the fertility maps may possibly contain some serious mistakes and should be re-examined in some localities.

3) In the study on interpretation and application of soil tests, work should be continued for those crops and nutrients which failed in the past trials or on which no work has yet been carried out. Attention should be given to the following points:

a. Treatments in the field trials for soil test calibration should be simplified, the number of replicates should be increased to 5 or more, and each nutrient should be tested separately. In other words, field data must be simple and exact. Non-compliance with this principle was probably the major cause for failure in many past soil test calibrations.

b. Effort should be made to attain uniformity in field management. For instance, heterogeneity of irrigation and land preparation is regarded as the greatest handicap in past sugarcane experiments.

c. A large number of trials must be conducted at one time in order to include as many existing interfering factors as possible. In this way, not only a more accurate generalization of results can be obtained, but also it is possible to detect and group together the interfering factors besides evaluating the trend and magnitude of their interferences.

d. In studying the influence of soil types on soil test interpretation, the soil samples should have been examined and classified into various soil management groups according to profile characteristics and yield levels. This will facilitate separate evaluation of soil test/fertilizer response regressions on the basis of soil management group. Those management groups showing similar trend of regression can be grouped together in making a fertilizer recommendation table for individual grades of soil test values.

Summary Table of Relatively Successful Soil Test Calibration Studies in Taiwan

Crop	Year	Institution	Type of soil	Soil nutrient studied	Best testing method	Correlation coefficient obtained[1]	Critical concentration (ppm)	Range of nutrient rate recommended (kg/ha)
Rice	1960–64	TARI	Latosol, Slate alluvial, Sandstone and shale alluvial	P	Bray No. 1	0.80**	20	0–80 P_2O_5
〃	〃	〃	〃	K	Mehlich	0.65**–0.79**	35 (45[2])	0–80 K_2O
〃	1962	〃	〃	Si	Na-acetate at pH 4.0	0.54*	40	0–2,500 slag
〃	1963–64	TPRF, PCHU	Latosol	K	Exchangeable	0.78**–0.81**	70	0–100 K_2O
Sugarcane	1952–54	TSES	Latosol	K	Exchangeable	0.55*	75 (90[2])	—
〃	1963–66	〃	"Podsolic-like"	P	Bray No. 1	0.68**	30	0–100 P_2O_5
〃	〃	〃	Acid soil	P	Bray No. 2	Significant	65	
〃	〃	〃	"Podsolic-like", acid soil	K	Exchangeable	Significant	80	0–200 K_2O
〃	〃	〃	"Weather depending"	K	Exchangeable	Significant	80	0–240 K_2O
Sweet potato	1964–66	TPRF, PCHU	Non-calcareous alluvial	K	Exchangeable	0.83**	70	0–240 K_2O (+5 MT compost)
〃	〃	〃	Calcareous and non-calcareous alluival	K	Egner	0.74**	60 (or 125 exch. K)	0–240 K_2O
Pineapple	1958–61	Touliu PES	Latosol, alluvial and colluvial	K	Exchangeable	0.75**	140	0–800 K_2O

(*Continued*)

Crop	Year	Institution	Type of soil	Soil nutrient studied	Best testing method	Correltion coefficient obtained[1]	Critical concentration (ppm)	Range of nutrient rate recommended (kg/ha)
Tobacco	1963	TRI	Sandstone and shale alluvial	P	Dyer	0.58**	150	—
Tea	1966	TTES	Latosol[3]	P	Bray No. 1 (40–60 cm depth)	0.92**	3	0–40 P_2O_5
Wheat	1966–68	PCHU, TPRF	Sandstone alluvial	K	Egner	0.72*	50	0–90 P_2O_5
〃	〃	〃	Non-calcareous slate and sandstone alluvial	K	Egner	0.74*	45	0–90 K_2O
Corn	1967–69	TARI	Sandstone and shale alluvial	P	Bray No. 1	0.62**	30	0–100 P_2O_5
〃	〃	〃	Schist and slate alluvial	P	Bray No. 1	0.68**	30	0–100 P_2O_5
〃	〃	〃	Sandstone and shale alluvial (sandy loam)	K	Mehlich (0–30 cm depth)	0.66**	50	0–100 K_2O
Sorghum	1969	TARI	Basaltic residual and alluvial (calcareous)[4]	P	Bray No. 1	0.81**	2	0–80 P_2O_5

1) For soil test values and percentage yields without added nutrient.
2) Proposed figure based on re-evaluation of the original report.
3) Only one location was involved in this study (correlation study was made among the replicates in one trial).
4) Penghu Islands.

A BRIEF INTRODUCTION TO THE 3-YEAR DRAFT PLAN FOR PROMOTION OF FARM MECHANIZATION IN TAIWAN

Chuang Chiao

In the past few years, agricultural development in Taiwan faced many difficulties among which the steady flow of farm labor from rural areas to industrial centers is particularly apparent. It accentuates the need for both the government and farm population to accelerate the rate of farm mechanization program promotion initiated by JCRR in 1954. The draft of the 3-year plan for promotion of farm mechanization in Taiwan was prepared only as a preliminary attempt, while more detailed measures and practical follow-up suggestions are absolutely necessary.

Before presenting this draft, the following problems concerning agricultural development and agricultural labor productivity are briefly discussed.

Modernization of Taiwan Agriculture

It is true that the proportion of agricultural product in the national economy is decreasing year by year (Table 1), though the importance of agricultural production to the growth of national economy remains unchanged. Therefore, the present problem is how to maintain stable growth of Taiwan agriculture.

Agriculture is also an enterprise the promotion of which depends on effective management, high efficiency, mass production, mass marketing, etc. Being handicapped by the small farms system, it can no longer compete with the other enterprises in modern society. In order to "modernize" Taiwan agriculture, effort should be directed not only to improve production techniques, but also to change the pattern of management while raising agricultural labor productivity.

Agricultural Labor Productivity in Taiwan

When compared with industry, Taiwan's agricultural labor productivity is rather low (Table 2). In 1969, for example, agricultural labor productivity was NT$14,841/worker, while that of industry was NT$57,216/worker. In other words, the latter was about four times that of the former while the population of agricultural labor (2,144,000) was about half of the total (4,337,000).

According to a survey made by PCHU in 1968, Taiwan farming operations depend mainly on man power with only rice culture partially mechanized as shown in Table 3. This is obviously the reason why agricultural labor productivity is so low. Thus mechanization of agriculture not only improves agricultural labor productivity, but it can also save a large proportion of farm labor for industrial development.

Outline of the 3-Year Plan

A. Title

3-Year Plan for Promotion of Farm Mechanization in Taiwan

B. Period of promotion

1970-1972

C. Executing agencies

MOEA, JCRR, PDAF, TFB, PFA, Taiwan Land Bank, the Cooperative Bank of Taiwan, NTU, PCHU, Provincial Pingtung Junior College of Agriculture, China Agricultural Machinery Co., and Shin Taiwan Agricultural Machinery Co.

D. Plan objectives

The kind and quantity of farm machines to be extended within the three-year period:

Item	Extension quantity (unit)		
	1970	1971	1972
Power tiller	6,500	7,500	9,000
Mist blower & duster	8,000	9,000	10,000
Water pump	10,000	10,000	10,000
Grain dryer	600	900	1,300
Rice transplanter	300	1,000	1,500

Note: According to the estimated demand of farm machines in the Fifth-Year Plan for Economic Development of the Province of Taiwan.

E. Outline of the plan:

1) Assisting farmers to purchase farm machines:

a. To subsidize farmers for purchase of farm machines at the rate of 10% of machine cost.

b. To provide farmers with farm machinery purchase loans bearing monthly interest of 0.5%.

2) Establishing farm machinery extension and service systems:

a. To establish township farm mechanization centers.

b. To organize farm machinery cooperative-use groups among farmers.

c. To organize farm machinery service teams among township FAs.

3) Reinforcing farm machinery/implements research, improvement and demonstrations: To determine priority of research on farm machinery/implements to develop more farm machinery, implements adaptable to the farming conditions in Taiwan and to introduce them to farmers through demonstrations.

4) Training farm machinery extension workers and technical personnel from farm machinery research workers, farm machinery operators and farm machinery extension workers.

5) Extending support to farm machinery manufacturers:

a. To provide farm machinery manufacturers with long-term low-interest loans to lower the cost of farm machinery.

b. To establish a farm machinery inspection system for raising the quality of farm machinery.

Table 1. National Domestic Product of Taiwan

(Unit: NT$ Mil.)

Year	Primary industry (Agriculture)	Secondary industry (Industry)	Tertiary industry (Service)	Total
1952	5,233	2,623	6,801	14,657
1953	7,436	3,433	8,677	19,546
1954	6,533	4,502	9,730	20,765
1955	8,028	5,162	11,497	24,687
1956	8,759	6,219	13,108	28,086
1957	10,163	7,648	14,653	32,464
1958	11,127	8,573	16,247	35,947
1959	12,591	10,632	18,391	41,614
1960	16,528	12,562	21,743	50,833
1961	17,872	14,240	24,975	57,087
1962	17,877	15,943	27,926	61,646
1963	18,819	19,810	32,120	70,749
1964	23,553	23,892	37,277	84,722
1965	24,810	25,912	41,166	91,888
1966	26,290	29,257	46,749	102,296
1967	28,281	33,937	53,214	115,432
1968	31,819	40,509	61,366	133,694

Source: Taiwan Statistical Data Book 1969, CIECD, compiled by RED.

Table 2. Labor Productivity of Taiwan

(Unit: NT$/worker)

Year	Primary industry (Agriculture)	Secondary industry (Industry)	Tertiary industry (Service)	Year	Primary industry (Agriculture)	Secondary industry (Industry)	Tertiary industry (Service)
1952	2,920	9,643	7,799	1961	9,347	36,795	22,102
1953	4,104	12,668	9,962	1962	9,234	39,216	23,991
1954	3,607	15,578	10,811	1963	9,543	46,722	26,306
1955	4,430	17,439	12,504	1964	11,718	54,424	29,561
1956	4,850	20,869	14,389	1965	12,300	57,710	31,936
1957	5,615	23,678	14,998	1966	12,824	61,335	34,809
1958	6,137	24,849	15,929	1967*	13,843	56,374	35,774
1959	6,795	29,370	17,399	1968*	14,841	57,216	41,324
1960	8,806	33,321	19,948				

* Methods of estimation changed

Source· Taiwan Statistical Data Book 1969, CIECD, compiled by RED.

Table 3. Average Labor-hour Requirement for Farming Operations of Fourteen Kinds of Crops in Taiwan

(Land Preparation—Processing for Storage)

Crop	Labor-hour/ha.				Percentage		
	Man power (A)	Animal power (B)	Machinery power (C)	Total (D=A+B+C)	Man power $(\frac{A}{D}\times100)$	Animal power $(\frac{B}{D}\times100)$	Machinery power $(\frac{C}{D}\times100)$
Rice							
1st crop	970	72	56	1,098	88.4	6.5	5.1
2nd crop	945	75	49	1,069	88.4	7.0	4.6
Sweet potato	833	142	24	999	83.5	14.1	2.4
Jute	4,085	178	6	4,269	95.7	4.1	0.2
Cotton	2,399	183	35	2,617	91.7	7.0	1.3
Wheat	1,543	27	7	1,577	97.9	1.7	0.4
Tobacco	4,418	141	81	4,640	95.2	3.0	1.8
Sugarcane	1,427	220	7	1,654	86.3	13.3	0.4
Tea	2,520	45	10	2,575	97.9	1.7	0.4
Peanut	1,382	83	10	1,475	93.7	5.6	0.7
Corn	1,381	189	40	1,610	85.8	11.7	2.5
Soybean	769	42	11	822	93.5	5.1	1.4
Sorghum	864	87	15	966	89.4	9.0	1.6
Pineapple	4,964	109	11	5,084	97.7	2.1	0.2
Banana	2,591	122	60	2,773	93.4	4.4	2.2
Total average					91.9	6.4	1.7

Source: A study on labor-hour requirement per unit farming operation of fourteen crops in Taiwan by Prof. H. T. Chen, 1968, PCHU.

A SURVEY ON THE UTILIZATION OF POWER TILLERS AND MIST-BLOWERS IN TAIWAN

Tien-Song Peng

The power tiller or hand tractor was introduced into Taiwan in 1954, and after a period of trial use it was soon extended to farmers in many districts. Since then the number of power tillers has been increasing steadily year after year. Up to the end of 1969, there were some 25,000 units of power tillers in use, and the rate of annual increase has been 4,000 units in the past two years, after the extension rate was raised and the machine size increased from 2.5 horsepower to 10 horsepower or more at present. Of late, not only power tillers but also other farm machines, mist-blowers in particular, have been used in increasing numbers in Taiwan.

In order to ascertain the effect of farm mechanization on agricultural management and the extent of farm machinery extension and utilization in rural areas, the Joint Commission on Rural Reconstruction and the National Taiwan University jointly conducted the first survey in 1960, when there were only 3,700 units of power tillers in use, about half of which were small sized power tillers under 4.5 horsepower. Again in 1965 JCRR and the Department of Agriculture & Forestry cooperated in taking random samples of 302 farm machine owners in different areas to determine the extent of power tillers in use, which had been increased to some 11,000 units with their size expanded to 10 horsepower. Meantime the average annual use of the machine was also increased to 629 hours from 447 hours five years ago.

The current survey jointly made by JCRR and the Harvest Farm Magazine began in September, 1969. The first two investigations were made by visits to farmer families to find out the scope and impact of using power tillers in contrast with the farmer families who depended on cattle for land preparation. At the same time changes in agricultural management patterns of the power tiller owners were studied through correspondence by sending questionnaire sheets together with the Harvest Farm Magazine to each family which used power tiller or mist-blower.

In this survey more than 700 answers were received from farm machine owners. After discarding those incomplete questionnaires, a total of 553 answers were obtained, among which 330 were from owners of large sized power tillers; 45 from owners of medium-small sized power tillers; 88 from users of above 51cc mist-blowers (mostly 70cc); and 90 from users of under 50cc mist-blowers (mostly 35cc). The main object of this investigation was to find out the cost of unit operation time of machine, which can be converted into operation cost per hectare. No attempt was made to investigate the change of the whole economic structure in rural areas.

Details of Investigation

A. Farm machine users and type of machines

Based on information from farm machinery manufacturers, farmers in Yunlin and Changhua have more power tillers than any other prefectures in Taiwan (Table 1), and they also submitted the highest percentage of answers to the questionnaires (Table 2), while farmers in Ilan Prefecture have the most number of medium-small power tillers.

Table 1. Number of power tillers in each prefecture/city
(September, 1969)

Prefecture/city	No. of power tillers	Percentage (%)	Prefecture/city	No. of power tillers	Percentage (%)
Taipei	1,189	5.01	Yunlin	3,187	13.43
Ilan	1,831	7.72	Chiayi	1,476	6.22
Taoyuan	1,721	7.26	Tainan	1,830	7.72
Hsinchu	669	2.82	Kaohsiung	1,831	7.72
Miaoli	568	2.39	Pingtung	2,393	10.09
Taichung	2,010	8.47	Taitung	529	2.23
Changhua	3,120	13.15	Hualien	619	2.61
Nantou	747	3.15	Penghu	3	0.01
Total:				23,723	100.00

Table 2. Number of families investigated and types of machines used

Prefecture/city	Power tiller				Mist-blower			
	Large		Medium-small		Above 51cc		Under 50cc	
	Family	%	Family	%	Family	%	Family	%
Taipei	2	0.61	1	2.22	1	1.14	0	0
Ilan	6	1.82	12	26.67	0	0	3	3.33
Taoyuan	24	7.27	4	8.89	8	7.09	7	7.78
Hsinchu	10	3.03	4	8.89	4	4.55	1	1.11
Miaoli	9	2.73	0	0	2	2.27	9	10.00
Taichung	34	10.30	6	13.33	3	3.41	8	8.89
Changhua	55	16.67	8	17.78	7	7.95	11	12.22
Nantou	16	4.85	3	6.67	6	6.82	8	8.89
Yunlin	52	15.76	1	2.22	8	9.09	4	4.45
Chiayi	41	12.42	1	2.22	9	10.23	10	11.11
Tainan	33	10.00	0	0	7	7.95	9	10.00
Kaohsiung	17	5.15	1	2.22	12	13.64	1	1.11
Pingtung	18	5.45	1	2.22	18	20.45	11	12.22
Taitung	5	1.52	2	4.45	0	0	2	2.22
Hualien	8	2.42	1	2.22	3	3.41	6	6.67
Penghu	0	0	0	0	0	0	0	0
Total:	330	100.00	45	100.00	88	100.00	90	100.00

B. General breakdown of subject families

As shown in the following Table 3, most of the families own 1-2.5 hectares of land, closely followed by those owning 2.6-5 hectares. Large power tiller owners have an average of 3.34 hectares; medium-small power tiller owners, 3.16 hectares; and large and small mist-blower owners, 2.56 and 2.52 hectares, respectively. Families with 4-6 persons working in the field are in the highest percentage group, followed by families with 3 persons or less and then families with 7-10 persons. Practically all the families in this survey possess radio, and 20-30% of them have TV sets and are newspaper subscribers. This fact signifies the high standard of living of these families. In the same table, we have also found that many families, or 61.52% of the total, who own power tillers still keep their cattle, particularly buffalo. The main reasons for this are: a) the large power tillers (rotary type) is less efficient in levelling paddy field than the draft cattle; b) most of the large power tillers are used for contract plowing for others, while part of the plowing work of the machine owners can be done by cattle; c) in case the machine breaks down they still can count upon cattle to do the plowing, or some small-scale farm work can be done better by cattle; and d) in some fields the paths leading to the field are either too narrow or fully planted with subsidiary crops to allow a power tiller to pass through. According to the survey made in 1965, 63.57% of the total power tiller owners were also keepers of draft cattle; this is very

Table 3. General breakdown of families surveyed

	Power tiller				Mist-blower			
	Large		Medium-small		Above 51cc		Under 50cc	
	Femily	%	Family	%	Family	%	Family	%
Area of cultivated land								
Under 1 ha	24	7.27	4	8.89	11	12.50	12	13.33
1.0-2.5 ha	123	37.27	20	44.44	43	48.86	46	51.11
2.6-5.0 ha	127	38.49	12	26.67	24	27.27	22	24.45
5 ha or over	56	16.97	9	20.00	10	11.37	10	11.11
Total	330	100.00	45	100.00	88	100.00	90	100.00
Average (ha)	3.34		3.16		2.56		2.52	
No. of persons working in the field								
1-3 persons	88	26.67	17	37.78	45	51.14	35	38.89
4-6 persons	126	38.18	20	44.44	22	25.00	38	42.22
7-10 persons	79	23.94	4	8.89	15	17.04	11	12.22
11 persons or more	37	11.21	4	8.89	6	6.82	6	6.67
Total	330	100.00	45	100.00	88	100.00	90	100.00
Average (person)	6.05		4.78		4.81		4.73	
No. of families keeping cattle	203	61.52	15	33.33	56	63.64	45	50.00
No. of families subscribing to newspapers	122	61.52	13	28.89	27	30.68	26	28.89
No. of families possessing radio	323	97.88	45	100.00	87	98.64	89	98.89
No. of families possessing TV	78	23.64	16	35.56	16	18.18	20	22.22
Total number of families	330	100.00	45	100.00	88	100.00	90	100.00

close to the 61.52% obtained in this investigation. However, only about one-third of the families possessing medium-small power tillers chose to keep their cattle, possibly because most of the machines are of the trailer type, which can easily do the work of cattle.

Size and Cost of Farm Machines

A. Size of machines

Of the 375 power tillers included in this investigation, 330 units or 88% belong to the large type of more than 10 horsepower each. Apparently, the size of power tillers is getting bigger as time goes on, when compared with the 60.6% of 302 sampled families who owned large type power tillers in 1965. The large and small types of mist-blowers would be about equal in number, if the percentage of the families surveyed were in direct proportion to that of the total number of farm machine owners.

Of the total number of large power tiller owners, 76.37% wished to own larger ones and only 19.37% preferred to buy the same type as indicated in Table 4. In other words, more than 95.76% of the large power tiller owners were either satisfied with what they owned or wished for larger ones. And 71.11% of the medium-small power tiller owners expressed their desire to own larger ones. Similarly, 89.77% of the large mist-blower owners were either satisfied with their machines or wanted to get larger ones, while 65.56% of the small mist-blower owners desired to have larger ones with only 33.33% preferring to have machines of the size owned. The number of farm machine owners who preferred smaller ones was negligible.

Table 4. Size of machines preferred

Type of machines preferred	Power tiller				Mist-blower			
	Large		Medium-small		Above 51cc		Under 50cc	
	Family	%	Family	%	Family	%	Family	%
Small size	64	19.39	10	22.22	47	53.41	30	33.33
Larger size	252	76.37	32	71.11	32	36.36	59	65.56
Smaller size	14	4.24	3	6.67	9	10.23	1	1.11
Total:	330	100.00	45	100.00	88	100.00	90	100.00

B. Cost of machines

The average cost of a large power tiller is NT$57,140, and that of a medium-small one, NT$34,478. This is close to the average market price of NT$55,000-59,500 for a large one and NT$28,000-42,000 for a medium-small one. According to the survey in 1965, 60.59% of the investigated families bought power tillers worth more than NT$50,000, whereas in this survey the percentage of large power tiller owners increased to 88%.

The price of a mist-blower has dropped somewhat in recent years, as the market price is NT$6,000-7,000 for a large one and NT$4,000-5,000 for a small one. But the average price of large and small mist-blowers, according to this investigation, was NT$7,229.50

and NT$5,678.90, respectively. Thus the cost of this kind of machine is still high, and is not profitable even for contract work.

Table 5. Breakdown of machines used

	Power tiller		Mist-blower	
	Large	Medium-small	Above 51cc	Under 50cc
Average first cost (NT$)	57,140.6	34,178.0	7,229.5	5,678.9
Average annual use in hours	858.2	606.1	369.8	383.3
Average salvage value (NT$)	14,225.9	7,144.4	1,465.9	1,236.3
Hours for tillage or spray (hr/ha)	14.72	27.80	5.52	6.26
Fuel consumption (liter/hr)	1.935	1.760	0.996	0.875
Oil consumption (liter/yr)	70.37	30.86	24.75	17.90
Labor cost (NT$/day)	106.2	110.0	91.2	102.6

Use of Farm Machines

A. *Service life of machines and their salvage value*

As indicated in Tables 5 and 6, the average service life of a large power tiller is 9.8 years, while that of a medium-small one is 11.32 years. The salvage values of the large and medium small ones are NT$14,225.9 and NT$7,144.4, respectively, or 24.89% and 20.72% of their respective first costs. The average service life of mist-blowers is seven years and their salvage values are 20.27% and 21.77% of the first costs for the large and small ones, respectively. It seems that the salvage values if exceeding 20% of the first cost, are rather high.

Table 6. Service life of power tiller and mist-blower by year

Year	Power tiller		Mist-blower	
	Large	Medium-small	Large	Small
Less than 3	4	0	1	2
3—6	30	2	33	36
6—9	112	12	35	30
9—12	120	15	14	18
12—16	49	12	5	3
16—21	13	4	0	1
21 or over	2	0	0	0
Total (unit)	330	45	88	90
Average (year)	9.8	11.32	7.08	6.93

B. *Annual use of machine*

The average annual use of machine is 858 hours or a total of 8,400 hours for a large power tiller, when a period of 9.8 years is considered as its service life; and 606 hours per year, or a total of 6,800 hours, for a medium-small one with a service life of 11.32 years. But, generally, the life of a diesel engine, which has become very popular now as the power source of power tillers, is expected to last 10,000 hours if it is well taken care of. By examining the factors and data above, we may conclude that the service life and annual use obtained from the investigation are still within reasonable limits, but whether it is economical or rational to use a machine when it has already become obsolete is beyond the scope of this survey.

In the 1965 survey, the annual use of power tiller was 629 hours, whereas in this investigation it has attained a 36.4% increase. In Japan, the life of a power tiller is 7.8 years, or 3,307 hours in total, with an annual use of 424 hours, as indicated in Table 7, which is comparatively less than that in Taiwan, possibly because most of the Japanese power tillers are of small types propelled by gasoline engines. All the mist-blowers used in Taiwan are powered by high-speed gasoline engines. The average service life of mist-blowers in this investigation is 2,600 hours which is only a little more than half of the 5,000 hours claimed by the manufacturers.

Table 7. Service life of power tiller in Japan by year

	Size of farms (ha)			Total/Ave.
	1.0—2.0	2.1—4.0	4.1 or over	
No. of power tiller surveyed	133	139	53	325
Distribution by years already served:				
1 yr.	—	—	—	—
2—4 yrs.	9	2	1	12
5—7 yrs.	57	73	27	157
8—10 yrs.	41	45	19	105
11—13 yrs.	23	17	5	45
14—16 yrs.	3	2	1	6
17 yrs. or over	—	—	—	—
Years already served	3.7	3.8	3.8	3.7
Years expected	4.2	4.0	3.8	4.1
Total service life	7.9	7.8	7.6	7.8

Data from the Northeastern Agricultural Res. Inst., Japan, 1969.

C. *Availability of machines*

As indicated in Table 8, no matter what kind of machines, large or small, they are either for own use or for others, especially when the rate of using large power tillers for others is about 56% of the total, which is quite close to that of 53.04% obtained from the survey in 1965. The situation of using power tillers for tillage and transportation has remained unchanged during the last four years.

Table 9 shows that in 1965 the rate of tillage was 20.37% for own farms and 29.08% for others; while the rates of 14.29% and 18.92% were for own transportation and for others, respectively. When compared with 26.8% for own tillage and 45.72% for others in the same table, the hours of using power tillers for land preparation showed great increase, particularly in doing work for others. But, on the contrary, the rate of doing transportation work for others decreased considerably as most of the medium-small power tillers were used on farmer's own farms and only 22.52% for others.

Table 8. Availability of machines

	Power tiller				Mist-blower			
	Large		Medium-small		Above 51cc		Under 50cc	
	hrs/yr	%	hrs/yr	%	hrs/yr	%	hrs/yr	%
Work on own farms.								
Tillage or spraying	230.1	26.81	327.5	54.03	174.9	47.30	179.4	46.80
Transportation	92.8	10.81	104.3	17.21	—	—	—	—
Work for others:								
Tillage or spraying	329.3	45.72	102.9	16.98	175.0	47.32	194.8	50.82
Transportation	85.5	9.96	33.6	5.54	—	—	—	—
Other	57.5	6.70	37.8	6.24	19.9	5.38	9.1	2.38
Total	858.2	100.00	606.1	100.00	369.8	100.00	383.3	100.00

Table 9. Availability of power tillers investigated in 1965

	Work on own farm		Work for others		Total	
	Working day	%	Working day	%	Working day	%
Tillage	16.01	20.37	22.86	29.08	38.87	49.45
Transportation	11.23	14.29	14.87	18.92	26.10	33.21
Pumping	9.67	12.30	3.43	4.36	13.10	16.66
Other	—	—	0.53	0.68	0.53	0.68
Sub-total	36.91	46.96	41.69	53.04	78.60	100.00

The working capacity of 19.44 hours per hectare was for a power tiller to do the work of paddy land preparation, according to the investigation of 1965, but it decreased to 14.72 hours per hectare in the present survey. This condition may be attributable to the larger size of power tillers. In Table 8, 230 hours were spent per year for tillage on own farms by using large power tillers. Four and a half times of tillage per year including cultivating and hilling work was required, as 3.34 hectares of average land area were owned by each family utilizing power tiller, and the time consumed for tilling a hectare was 14.72 hours. The hours needed per year for doing the same work for others amounted to 392.3 hours with the same number of farming operations. A large power tiller could do the same amount of work for others in an area of 5.68 hectares. In other words, the total area of tillage per year with a large power tiller was 9 hectares.

The time spent for tilling one's own farm with a medium-small power tiller was 327.5 hours and for others, 102.9 hours The average farm size per owner of this type of machine was 3.16 hectares and the time consumed totaled 27.8 hours per hectare. Thus an average of 3.8 times was required per year for performing tillage work. A medium-small power tiller could easily take care of a hectare each time for others. It means the total area of tillage with a medium-small power tiller for own farm and others was 4 hectares a year. Likewise, a mist-blower may be able to serve 5 hectares of land each year with a land area of 2.54 hectare per owner of mist-blowers, if the time spent on own farm and others is equal.

Cost Analysis of Machine Ownership

A. *Depreciation*

In this survey the depreciation of farm machinery is calculated by the straight-line method which reduces the value of a machine by an equal amount each year during its service life. According to the results of this investigation, the total operation cost of large power tillers is NT$31,422 per year, including depreciation charge of NT$4,377.7, which is 13.93% of the total, and 21.86% in cash expenditure, exclusive of operator's wages, as shown in Table 10 and 11. When compared with the 1965 investigation showing depreciation of NT$5,340, being 35.86% of cash expenditure, the present figure of depreciation is 14% lower. However, the depreciation of power tiller in this investigation is only 7.4% of the first cost and that of the medium-small power tiller, 7.04%, which are considered too low due to the longer service life of the machine and the over-estimated salvage value.

The depreciation of a large mist-blower is NT$814.1, representing 11.26% of the first cost, or 10.17% of the total operation cost; while that of a small one is NT$640.9, which is 11.28% of the first cost, or 8.01% of the total operation cost.

Table 10. Cost analysis of power tiller and mist-blower

	Power tiller				Mist-blower			
	Large		Medium-small		Above 51cc		Under 50cc	
	NT$/yr	%	NT$/yr	%	NT$/yr	%	NT$/yr	%
Operation cost per year:								
Depreciation	4,377.7	13.93	2,414.7	12.44	814.1	10.17	640.9	8.01
Interest on investment	4,110.7	13.08	2,397.4	12.35	501.1	6.26	398.3	4.98
Repair and maintenance	2,277.4	7.25	1,105.8	5.70	254.8	3.18	243.9	3.05
Fuel cost	6,642.5	21.14	4,266.9	21.99	1,473.4	18.41	1,341.6	16.77
Oil cost	1,125.8	3.58	493.8	2.54	396.0	4.95	286.4	3.58
Miscellaneous	1,494.8	4.76	395.6	2.04	374.8	4.35	175.4	2.18
Labor cost	11,393.1	36.26	8,333.4	42.94	4,215.7	52.68	4,915.8	61.43
Total operation cost:	31,422.0	100.00	19,407.6	100.00	8,002.9	100.00	8,002.3	100.00
Operation cost per hour	36.61		30.20		21.64		20.83	
Operation cost per ha	538.9		839.4		119.5		139.7	
Average charge for other's work (NT$/ha)	1,004.6		1,193.7		121.5		122.2	

B. Interest on investment

The monthly interest rate of 0.96% for farmers' loan is usually charged by the Taiwan Land Bank, calculated according to the following equation:

$$\text{Interest} = 0.0096 \times 12 \times (\text{first cost} + \text{salvage value})/2.$$

The interest on power tiller in this investigation is NT$4,110.7 which is about one thousand dollars more than the value of the machine in 1965. Possibly, this is due to the increased first cost of large machines and the over-estimated salvage value. However, the interest charge of 20.52% of the cash expenditure is quite close to 20.45% in the 1965 investigation. It is evident that if we ever want to lighten the burden of farmers, we should urge the farm machinery manufacturers to try their utmost to lower the sale price, while asking the bank authorities to further reduce the rate of interest on loan to farmers.

Table 11. Comparison of cash expenditures for using power tillers

	1965		1969			
			Large		Medium-small	
	NT$/yr	%	NT$/yr	%	NT$/yr	%
Depreciation	5,340	35.86	4,377.7	21.86	2,414.7	21.80
Interest on investment	3,046	20.45	4,110.7	20.52	2,397.4	21.65
Repair and maintenance	2,965	19.91	2,277.4	11.37	1,105.8	9.99
Fuel cost	2,639	17.72	6,642.5	33.17	4,266.9	38.53
Oil cost	782	5.25	1,125.8	5.62	493.8	4.46
Miscellaneous	121	0.81	1,494.8	7.46	395.6	3.57
Total	14,893	100.00	20,028.9	100.00	11,074.2	100.00

C. Repair and maintenance

The cost of repair and maintenance of a large power tiller is NT$2,227.4 and that of medium-small ones, NT$1,105.8, showing a decrease from the average cost of NT$2,965 in the last investigation. The same cost for the entire service life of large or small power tillers and mist-blowers is 25-35% of the first cost, denoting that the machines are in good repair and maintenance. This phenomenon may be attributed to four factors: a) the level of farmers' technical skill in using, repairing and maintaining machines has been raised; b) the quality of the machines has been much improved; c) the manufacturers offer better after-service; and d) the first cost of farm machinery is high. But, if the required self-maintenance hours were converted into wages, the cost of repair and maintenance might be higher.

D. Fuel cost

Of the total cost, the fuel charge occupies a considerable proportion, next only to wages but much higher than depreciation, interest, and repair and maintenance combined, as shown in Table 10. This situation presents a sharp contrast to that of 1965 investigation.

For example, the average fuel cost of a large power tiller is NT$6,642.5, which is one and half times higher than NT$2,639 in the last investigation (Table 11). The principal reasons for the high cost are the high fuel price and increased operating hours. In order to reduce the operating cost to accelerate the development of farm mechanization in Taiwan, the fuel cost for farm machines must be lowered at least to the level of the special price offered to fishermen by the China Petroleum Corporation.

E. Lubrication and miscellaneous costs

Both the lubrication and miscellaneous costs are from 2 to 5% of the total operating cost. Though this sum is low enough, the amount of money involved is somewhat higher than that in the last investigation.

F. Labor cost

As shown in Table 5, the average wage during the busy farming period is about NT$100 per day. The machine operators are mostly men. Suppose that working time averages 8 hours per day, then the labor cost for one-year machine operation can be calculated (Table 10). Of course, the working time may be over 10 hours per day during the busy farming season, thus the actual expenditure in wages should be less. As a matter of fact, the percentage of labor wages is always higher than any other factors in the total operation cost. For example, labor cost is 36.26% for the large power tillers; 42.94% for the medium-small power tillers; 52.68% for the large mist-blowers; and 61.43% for the small mist-blowers. This shows that labor cost for small machines is considerably higher than that for large ones.

Advantages of Using Machines

A. The total operation cost and the cost of unit hour or unit area

As shown in Table 10, the annual average cost for operating large power tillers is NT$31,422; that for operating medium-small power tillers, NT$19,407; and that for operating large and small mist-blowers, NT$8,000. When converted into cost per hour, they are NT$36.61 and NT$30.20 for large and medium-small power tillers, and NT$21.64 and NT$20.88 for large and small mist-blowers, respectively. But large machines have a higher field capacity than that of small ones, thus accounting for the low cost per unit area of the large machines. As an example, for tilling one hectare of land, NT$538.9 is required of a large power tiller and NT$839.4 required of a small power tiller, or about 50% more than the former. And the cost per hectare for operating a small mist-blower is NT$130.7, which is higher by 10% than NT$119.5 for operating a large one. Thus, it is economical to use large machines.

B. Comparison between income and expenditure of machine owners

According to this investigation, when a power tiller is used in others' paddy field, the charge is NT$1,004.6 per hectare for the large type and NT$1,193.7 for the small type. The reason for the higher charge for using a small power tiller is that it is equipped with a plow, giving better performance in land preparation though having low working capacity. Therefore, it takes 27.8 hours for a small power tiller to till a hectare of land, much more than the 14.72 hours per hectare for using a large power tiller. Although the charge for using a medium-small power tiller is high, the gain is less because of the high operation cost.

In this survey the charge for using a mist-blower to spray chemicals for others is NT$120 per hectare. Because of the high operation cost there is no profit to speak of in using the large type, and the income from small mist-blower is not even sufficient for covering the cost of operation. However, the operating hours may be lengthened to lower the cost per unit hour. Meantime, wages constitute more than 50% of the total cost among the cost factors, thus using a mist-blower to spray for others can at least count on earning wages.

In view of the above findings, it suffices to say that those who make use of small farm machines have to pay higher wages and also higher cost of operation than those making use of large ones. Therefore, if the field size is large enough to allow the use of large machines, it is more economical to do so. In recent years, plowing others' fields for extra income has become a prevailing practice. This accounts for the farmers' demand for machines of larger horsepower in order to cover more land area. In the future it is quite possible that tractors may be used for field operations just as tractors have been extended to farmers in Japan. As long as natural conditions limit the use of larger machines, small farm machines will continue to do their part in the development of rural economy. In addition, this investigation reveals that by using large machines the cost of unit area plowing and spraying is less than that by small machines, and that the profit derived from working for others is also higher than that of small machines. Thus the advantages of using large machines are self-evident.

Conclusion

The items listed on the investigation sheets in this survey seem too complicated for the average farmer to answer, and some items require careful consideration and judgment on the part of the farmers. From this survey, we know that the machine owners in Taiwan are able to use their machines more reasonably and efficiently than before, and that the level of education of the farmers in this survey is relatively high.

Based on the results of this survey it is established that there is a persistent tendency toward purchasing larger farm machines among Taiwan farmers, and that using power tillers or mist-blowers to work for others is still common in the rural areas, while using power tillers for transportation purpose is decreasing significantly. Except for transportation, a large power tiller can take care of 9 hectares per year, while a medium-small power tiller only averages 4 hectares. And a mist-blower can fulfill the spraying job on 5 hectares of paddy land a year.

From cost analysis, we have found that the use of large farm machines is more profitable than that of small ones, provided favorable working and environmental conditions exist for using large farm machinery. This survey also shows that the cost ratio for using a large power tiller as compared to a small power tiller is 1 to 1.5, while that for using a large mist-blower compared to a small one is 1 to 1.1. The cost of labor for large type machines occupies a smaller share in the total cost than that of small types, as the wages for operating a large power tiller and a large mist-blower are 6.68% and 8.75% less, respectively. In Table 10, the percentages of wages and fuel cost are quite high: 57.40% for a large power tiller, 64.93% for a medium-small power tiller, 71.09% for a large mist-blower, and 78.20% for a small mist-blower. If we aim at reducing the cost of operating farm machines, we should try to uplift the working capacity of machines in order to lower labor cost on the one hand, and to cut down fuel price on the other.

In analysing the cost of farm machines, both depreciation and interest on investment are still high. To reduce the first cost of farm machines and simultaneously the interest rate of bank loans is a matter of paramount importance. In 1957, the Taiwan Land Bank, the Cooperative Bank of Taiwan and the Taiwan Food Bureau began parcelling out loans for farmers to purchase farm machines. The interest on the loans from the Taiwan Food Bureau was reduced from 0.0099 in 1957 to 0.009 monthly in 1963, and then further reduced to 0.0075 now, but the borrower has to repay the loan according to the price of rice at the time of payment. Likewise, the interest on loans from the Taiwan Land Bank was reduced from 0.012 in 1961 to the present rate of 0.0096. The repeated lowering of the interest on loans clearly demonstrates government effort in reducing the cost of farm machines. It is our hope that the interest rate can be further reduced, thus speeding up the process of farm mechanization.

In conclusion, this survey not only gives a bird's-eye view of the cost of using farm machines in Taiwan, but also makes mention of ways how to reduce cost in order to hasten the adoption of farm machinery. Only when the cost of farm machines is lowered to the extent that it is within the reach of the general agricultural population, can the farm mechanization program take great strides in its progress on this island.

AERIAL APPLICATION OF PESTICIDES BY HELICOPTERS IN TAIWAN

Hong-Ji Su

In Taiwan today, pesticides of about NT$600,000,000 worth are used to combat destructive pests in the field, because the island's climatic conditions and the intensified cropping systems adopted are favorable to pest incidence and prevalence. And some NT$200,000,000 in labor cost is spent each year to apply such a bulky amount of pesticides to the fields on this island. Meantime, the shortage of labor supply for managing field operations has become serious year after year, and it will be more so in the near future when a greater number of rural labor is absorbed by industry. Under the circumstances, mechanization of pesticide application by helicopters is considered necessary to improve plant protection work in Taiwan.

In 1918, fixed-wing planes were first tried in the application of insecticides in Nevada, USA, and in 1945 helicopters with pesticide sprayers attached were used for the first time in the same country. Thenceforth, aerial application has become a popular practice of plant protection in many Western countries confronted with a shortage of agricultural labor as a result of rapid industrialization.

In recent years, there are about 7,000 aircraft in Russia, 5,000 in USA, 500 each in Central America and Australia, and 150 in Japan used for aerial spray of pesticides. Fixed-wing planes have been used mostly in America and Europe, while helicopters are in common use in Japan. The spray efficiency of aerial application is 40 times higher than that of ground spray, and the spray cost is comparatively lower in comparison with ground application.

Helicopters are much more suitable than the other types of aircraft for aerial spray in Japan, according to investigation and field trials made in 1953. Some 160 helicopters were used last year, more than 80%. of which were for the control of rice pests.

Aerial application of pesticides was first tried in Taiwan in 1967 under projects initiated by JCRR. Based on the results of trials, aerial spray became practicable and worthy of extension on this island, particularly during the period when shortage of agricultural labor is keenly felt in most parts of Taiwan.

In the first-year test, field trials were made to control rice blast and virus or mycoplasma-like diseases. The experimental results revealed that the test diseases could be effectively controlled, especially virus or mycoplasma-like diseases, because in the paddy fields sprayed by helicopter, the disease incidence was 35.6% less than those subjected to ground spray.

Rice farmers usually do not spray waste land and foot paths adjoining the paddy fields, where leaf hopper, vector of the diseases of transitory yellowing and yellow dwarf, take refuge. By aerial application, however, the insect vectors in a certain area can be eliminated, when the insecticide area is sprayed evenly from the air. So, this practice is considered the best way to wipe out the widely distributed diseases.

The field trial of aerial application was continued in 1968 to improve the techniques of aerial application in Taiwan, particularly to find out the workability of the ultralow volume application of pesticides by helicopters. The resultant data indicated that aerial application could be applied for effective control of the highly transmissible and most destructive rice pests such as rice blast, vectors of virus or mycoplasma-like diseases and stem borer.

The ultralow volume application of non-mercury fungicide (Kasumin) could control rice blast better or as effectively as the low volume application of aerial spray. Moreover, the new spray technique costs 30% less as compared with the ground spray. The same is true of the ultralow application of malathion LVC (95%) which reduced 16.6% of white earing caused by stem borer and raised 10.5% rice yield in comparison with ground spray.

In 1968, aerial spray was also tried to control banana Sigatoka disease in the Pingtung area. It showed that aerial spray gave better control of the disease because of uniform coverage of chemicals over the young upper leaves of banana in comparison with ground spray. In the case of Sigatoka control, each newly produced leaf has to be protected by fungicide, whereas in ground application the fungicide cannot reach the upper leaves due to the interference of spray beam by lower leaves.

The banana growers are now aware of the fact that better and more effective control of Sigatoka disease can be achieved by means of aerial spray, and that banana plants sprayed by helicopter will bear fruit of uniform quality in the whole area. As aerial spray can cover a large area of banana plantation within an appropriate period, all banana plants in a large area can be uniformly sprayed on a cooperative basis. Uniform banana quality is much sought after for grading of bananas prior to packing and shipment.

It was planned in 1969 to conduct a large-scale aerial spray program over 6,000 ha of banana plantations in the Kaohsiung area. Unfortunately, repeated typhoon disasters made havoc of banana plantations in the target area. Thence, the operation of the spray program was not up to expectations because of natural disaster in addition to occasional breakdown of helicopters. Three of the 5 helicopters used failed to function mainly due to unskilled pilots and partly through engine trouble.

For 1970, some 10,000 hectares of banana groves are scheduled to be sprayed by helicopters in 10 spray cycles. It is expected that the helicopters will give better performance to fulfill the assigned task, and that this newly introduced spray technique will be further extended to other parts of the island following vigorous promotion of farm mechanization throughout the island.

The following are the technical

and administrative problems we are still facing before extensive aerial spray can be carried out in the whole province:

1. Shortage of qualified pilots: So far, there is not a single organization under the government responsible for training of agricultural pilots. This problem has to be effectively dealt with for efficient operation of agricultural aviation companies.

2. Promulgation of agricultural aviation regulations and establishment of an organ for administering agricultural aviation setups.

3. Formation of an agricultural aviation association or a promotion committee for work coordination, mapping out technical standards ond settling disputes on spray wages and spray schedules between farmers and aviation companies.

4. Modification of the present crop cultivation systems to make them suitable for aerial spray and farm mechanization. For instance, consolidation of land and integrated demonstration of improved rice cultivation are much favored for the promotion of aerial application of pesticides, herbicides as well as fertilizers.

TWO MAJOR FIELD PROGRAMS ON RICE PEST CONTROL

Ren-Jong Chiu

A previous report made at the PID staff meeting summarized the rice disease situation in Taiwan under the influence of changing cultural practices. The present account will review two major JCRR-financed field programs on the control of rice diseases and insect pests during 1961-1970.

Cooperative Rice Pest Control Program

For the last ten years, "cooperative rice pest control" has been a major program which signifies a great joint effort by JCRR, government agencies and rice growers to increase rice production. The principle of cooperative control was first tested in 1961 when demonstration was first organized jointly by JCRR, PDAF and PFB at 10 different townships to compare the effectiveness of pest control by team operation with what was done on the individual farm basis. In 1962, sixty-two more of such teams were organized. The idea behind such program is that unified operation to combat diseases and insect pests could more efficiently and thoroughly remove the infection or infestation sources, thereby augmenting the effect of each single operation. In case a pesticide is used, its effectiveness can be better assured if the choice of pesticide and the timing of its application are properly planned. The program has made this possible by channeling technical guidance from the various district agricultural improvement stations to farmers' teams through short training courses, discussion panels and other means.

Except five townships which entered the program as township-wide demonstration units, each team usually consists of 50 or more farmers who are farming in adjoining rice fields totaling 50-100 ha. This total area of rice fields constitutes a demonstration unit for the practice of cooperative pest control. Each team has a leader, usually an enthusiastic and well trained person, who disseminates technical information from the government extension workers and coordinates all activities within the team. Application of pesticides is scheduled jointly by the team leader and township extension workers, with the assistance of PDAF and the district agricultural improvement station technical personnel. To raise the knowledge level of the team leaders and selected members, PDAF sponsors short training courses once in each rice season. Frequent discussion sessions are also held within or among the teams. The first two years of demonstration of cooperative pest control shows that rice yield from the demonstration fields could be raised by 11 to 14% over those fields where pest control was carried out but not well-coordinated.

Encouraged by the above results, JCRR, PDAF and PFB jointly launched in 1964 a five-year program on cooperative rice pest control in which county /city governments also participated by providing matching funds. It has been so planned that each year a certain number of townships are selected to set up demonstration teams of the size described above. Extension effort will follow in the following year when the remaining rice farmers in the same townships are organized into extension teams, the number of which varys with the rice acreage in each township. PDAF and PFB are responsible for organizing demonstration and extension teams, respectively. Subsidies are given to each participating township for the first two years of demonstration to cover partial cost (about 50%) of sprayers and dusters purchased for cooperative pest control purpose. Training classes are provided for the benefit of township extension workers, leaders and selected members of the cooperative pest control demonstration and extension teams. From 1964 to 1968, a total of 321 demonstration teams and 2,078 extension teams were organized in 303 townships. The following table gives the details:

Table 1. A summary of data on cooperative rice pest control in Taiwan

Year	Cumulative number of cooperative pest control teams			No. of participating farmers	No. of participating townships	Rice acregae covered (ha)
	Demonstration	Extension	Total			
Existing prior to 1964	72*	—	72*	—	72	—
1964	221	160	381	35,793	111	35,799
1965	271	825	1,106	124,013	161	112,002
1966	321	1,335	1,656	200,491	210	172,503
1967	321	1,585	2,082	254,814	276	218,213
1968	321	2,078	2,399	300,299	303	251,932

* Including five township-wide teams.

Execution of the cooperative pest control program during the last ten-year period has produced the following desirable results:

1) An increased yield of rice per unit area to an extent, which, however, was determined by climatic and cultural factors that would combinely affect the level of disease and insect incidence otherwise. According to data collected during 1965-1966 by PDAF, the cooperative pest control demonstration fields averaged 11-13% higher yield over those in which rice growers conducted pest control on an individual farm basis according to their own judgment. Along with this yield increase was an increased net profit of the same magnitude for those farmers participating in the program. The difference in these comparisons became narrower in later years as the non-participating farmers gradually learned to follow the same pattern of pest control used in the cooperative fields.

2) A raised level of knowledge of

rice pests for the township extension workers and farmers. This is, by far, one of the most significant achievements of the program.

3) An organizational basis on which to impose later in some selected townships the so-called "integrated demonstration program on improved rice cultivation techniques" for an even greater increase in rice yield.

Undoubtedly, such an extensive pest control program tends to encourage the use of pesticide, sometimes to an extent beyond actual need. That Taiwan's rice growers in many major areas spend a sizable sum of money, about 20% of the cost of rice production, on controlling rice insects and diseases seems to attest this undesirable side effect. Except in Japan where pesticide use in the rice field is even more extenisve, Taiwan's farmers are not surpassed in pesticide expenses by their counterparts in any other rice growing countries of the world. To correct this trend may require more fundamental knowledge of the disease and insect ecology plus sustained efforts in developing varieties with multiple resistance to major diseases and insects.

The present state of cooperative pest control activities differs somewhat from township to township. In those townships where responsible extension personnel remain devoted to their work, the program is being continued with vigor. In others interest in cooperative activities is gradually lost as a result of suspended government subsidy. This is so particularly under the present condition of decreased profit for farmers growing rice. One outgrowth from the program, unexpected at its start, has been the emergence of pesticide application as a profession in many townships previously benefited from cooperative pest control program. Some of those who now provide this service received subsidies in the past to purchase dusters or sprayers. Although such development is not entirely undesirable, it was not the original intention.

Perhaps, the aerial application of pesticides first on experimental trial in the rice field in 1967 in Taiwan can be considered as another way of practising cooperative pest control principle, though at a higher level of mechanization and efficiency. The target diseases and insect pests include blast, borers, leafhoppers and the leafhopper-transmitted virus or virus-like diseases, i.e., yellow dwarf and transitory yellowing. The annual rice acreage under aerial pesticide application has been fluctuating from about 3,000 hectares to 4,500 hectares in the last four years. Evidently, wide acceptance of this new technique has not yet been achieved and government subsidies are still needed for sometime before private enterprises can take root in establishing their business.

Forecast Service on Rice Diseases and Insect Pests

To contemplate providing fundamental information necessary for the prediction of occurrence of rice blast, a study on disease ecology was begun in 1962 at the Chiayi Agricultural Experiment Station (Chiayi AES). This work placed emphasis on determining the relationships of weather conditions to the formation of fungus spores and the incidence of disease in the field. In the following three years, the same type of studies was also implemented at three other stations, namely, the Taichung, Taipei and Kaohsiung District Agricultural Improvement Stations (DAIS's) while the Chiayi AES remained the center where more critical studies were conducted. At the latter, daily records of air temperature, humidity, and precipitation were taken throughout the year. The number of blast spores in the air was also trapped and observed every day. During the rice seasons, the investigators determined daily dew duration, examined daily amount of infection on rice seedlings of uniform age and inspected the experimental rice fields at weekly intervals for the degree of blast incidence. Although no reliable bases applicable to wide areas for blast forecasting have been derived from the above studies, the stations involved did provide useful service to rice growers in their respective areas by releasing the results of their observations as a guide for blast control. Indeed, the practical purpose served through the above studies and a parallel study on rice borers, both financed by JCRR, stimulated interest in establishing a province-wide network for the prediction and forecast of major rice diseases and insect pests.

The network first took its present form in 1966 under a JCRR-financed program. In the organizational aspect, it involves the PDAF, functioning as the main station (or the headquarters) for the service, the seven DAIS's, functioning as sub-stations, and some fifty observation posts (or checkposts) at selected townships throughout the island. At both the main station and the sub-stations, one specialist each, usually a college graduate with several years of experience in field research either in plant pathology or entomology, is assigned his main work relating to forecast service. He is assisted by one or more persons with agricultural vocational school training. Upon implementing the service, recruitment of fifty agricultural vocational high school graduates to work full time under the program was made. Except the seven who are attached to the DAIS's, the remaining 43 are stationed at 43 different places throughout the island. These fifty men serve as checkpost observers (for their distribution, see Table 2).

At each checkpost, an experiment field is contracted from the farmer each season, in which a light trap is installed for daily collection of pest insects. Counts are obtained for such major insects as rice borers, green rice leafhoppers and brown rice planthoppers. Catching of these is also made at regular (5-day) intervals from other farmers' fields by means of a power catcher. To determine the density of air-borne blast spores, a glass slide is exposed daily in the experimental field and brought to the DAIS where microscopic examination is made. The checkposts are not equipped with weather-recording instruments, but weather records are provided to the observers from a weather-recording set-up nearby for irrigation and other purposes.

One of the more important activities of these 50 checkpost observers is to conduct field inspection in their respective areas for early detection of any destructive diseases and insects. All information gathered by the checkpost observers are referred back to the DAIS for compilation and analysis. Each checkpost observer is provided with a motorcycle as a convenient means of

Table 2. Number and distribution of observation posts for rice pest forecast service in Taiwan

Sub-station to supervise	County/City	Rice acreage* (ha)	Number of observers assigned
Taipei DAIS	Taipei City Yangmingshan	6,803	1 1
	Taipei County	38,421	5
	Ilan	40,891	2
	Keelung	672	1
Hsinchu DAIS	Taoyuan	82,692	2
	Hsinchu	36,635	2
	Miaoli	37,226	2
Taichung DAIS	Taichung City	12,055	1
	Taichung County	56,724	3
	Changhua	105,993	4
	Nantou	27,328	2
Tainan DAIS	Yunlin	74,747	3
	Chiayi	47,687	3
	Tainan City	3,603	1
	Tainan County	51,249	5
Kaohsiung DAIS	Kaohsiung City	6,135	1
	Kaohsiung County	39,632	4
	Pingtung	76,737	4
Taitung DAIS	Taitung	19,495	2
Hualien DAIS	Hualien	21,867	2

* According to 1969 statistics.

transportation. To help the observers in early detection of major diseases and insects in the field, a certain number of rice growers are subsidized to make field inspections and report their findings to the checkpost observers.

At the sub-stations, besides various data taking as is done at the checkposts, some ecological studies on diseases and insects are made in line with the forecast work. For example, dry seed beds are set up at the Taichung DAIS to determine the level of blast incidence affected by the seasons. At both the Taichung and Tainan Stations, laboratory rearing of borers is conducted to determine the time of emergence for these major insect pests. However, the main responsibilities of the sub-stations have been the evaluation and analysis of information and data obtained from the checkposts and, when necessary, the issuing of warnings to townships, co-operative pest control teams and farmers. There are two different warnings which may be issued according to the field situation. Alert warning is intended to call the attention of rice growers to early detection of certain diseases or insects. Outbreak warning is intended to call for action by the farmers or township extension workers responsible for pest control field programs. General information of province-wide interest is compiled and released by the PDAF.

In addition, the PDAF also sponsors various kinds of training classes for forecast workers at different levels.

One major event relating to the forecast service took place in 1968 when regular positions were created under PDAF for those 50 checkpost observers who had been so far employed as temporary employees under the JCRR-financed program. With this development, the forecast service gained permanent status, at least, in its organizational aspect.

It should be understood that the service established to forecast rice diseases and insects in Taiwan is not comparable to that for potato leafblight in some European countries and in the United States. It is patterned after what has long been adopted in Japan and functions likewise. The significance of such service lies in the fact that field inspection by 50 checkpost observers and subsidized farmers makes early detection of certain diseases and insects possible and that through direct contacts these observers assist in carrying-out pest control field programs, taking the cooperative pest control program as an example. Although the sub-stations issue outbreak warnings whenever weather data and field evidence call for such issuance, no attempt has been made to determine the degree of precision.

The ability to forecast a disease or insect incidence for a major crop can be of great importance if effective and economical control is to be obtained. This is especially so when the trend becomes evident toward using pesticides of greater safety with shorter residual effect. In order to develop such an ability some fundamental studies are needed. A sound basis for predicting the level of disease and insect incidence can be established only after acquiring a full knowledge of the ecology of the diseases and insects concerned. Apparently, such knowledge does not exist for any major rice diseases and insects of Taiwan. Accurate prediction and forecast have been made more difficult because of the much devided paddy fields which are planted with different varieties at different dates. Therefore, a meaningful forecast with any precision will await not only a full knowledge of disease or insect ecology but also uniformity in planting time as well as of varieties planted. This would not be obtainable in the foreseeable future.

THE WITCHES' BROOM OF SWEET POTATOES IN TAIWAN

Tsong-Tseat Lo

Since 1968, the Witches' broom of sweet potatoes has been found to exist in the fields of Taiwan. Serious attention was immediately given by the plant pathologist of Plant Industry Division JCRR, and a control plan was worked out by JCRR and condueted by PDAF as follows:

1. A province-wide survey on the occurrence of the disease was made by PDAF. The resultant data revealed that diseased plants were sporadically distributed among 49 townships of nine counties. In some localities of Miaoli, Hsinchu and Penghu, the disease was particularly serious where the rate of diseased plants was as high as 60%, while in the other counties, it was only 0.1-2.0%.

2. A study on the pathogen of the disease was carried out by the National Chung Hsing University with an electron microscope. Mycoplasma was abundant in the phloem elements of the diseased plants. This is a new micro-organism first reported by a Japanese plant pathologist in 1967 and is now believed to be the pathogen of the disease.

Diseased vines treated with Tetracycline was also tested in the National Chung Hsing University. Preliminary results showed that 25, 50 or 100 ppm of Aureomycin and Rondomycin brought about an effective cure.

3. The insect vector of the disease has been studied by the Hsinchu and Tainan DAISs. No *Nesophrosyne orientalis* (黑斑浮塵子), which was reported as the vector of the disease in Okinawa, was found in the fields of Hsinchu area so far. However, a different species of *Nesophrosyne* has been proved responsible for transmitting the disease by the Hsinchu DAIS, and identification of the species is underway.

4. Use of disease-resistant varieties of sweet potatoes is emphasized as an important measure to control the disease in Taiwan. Because of the large acreage of the crop (annual cultivation being 230,000 ha) and its wide distribution in every corner of the island, control of the disease should depend mainly upon the use of resistant varieties coupled with the control of insect vector at proper times.

Testing on resistant varieties of sweet potatoes has been tackled by the Chiayi Agricultural Experiment Station. Tested varieties are planted in pots and grafted with diseased vines from the field.

Up to the present, 12 out of 285 tested commercial varieties have been found relatively resistant, but no varieties are immune from the disease. The joint efforts in the above studies are being continued.

In the spring of 1970, around 200 hectares of sweet potatoes in the Pei-sha Township of Penghu County were selected as a location to demonstrate disease control. Some 2,300,000 healthy planting vines of the commercial variety Tainung 45, which is highly resistant to the disease with desirable agronomic characteristics, were shipped to Penghu to replace the susceptible ones. Three sprays of "Sevin" at intervals of three weeks were applied to the fields to control the vectors.

OCCURRENCE OF BANANA WILT IN TAIWAN

Ren-Jong Chiu

Banana wilt, or more commonly known as Panama disease of the bananas, was not recorded from Taiwan until very recently. According to Mr. Ching-kuo Chu, horticulturist of the Chiayi Agricultural Experiment Station (Chiayi AES), suspicious cases used to be spotted in the vicinity of Tainan and Pingtung areas attacking only Luzon Chiau, a "Lacatan type" variety of minor importance. In these areas, it was the growers' practice to replace the diseased Luzon Chiau plants with suckers of the main commercial variety, Peichiau, as a means of disease control. The latter variety has been considered highly resistant, and productive growth is often possible even in the infected soil. In early June, 1969, taking advantage of Dr. William Snyder's visit to Taiwan, a field trip was arranged to inspect some banana farms in Chia-li, Tainan, suspected of Panama disease infection. Among those accompanying him were Mr. Y. P. Tsai of BCIQ and myself. In one small banana farm several Luzon Chiau plants with Panama disease syndromes were observed. Some diseased specimens were taken back to Mr. Tsai's laboratory for isolation of the causal organism. A pure culture of *Fusarium* thus obtained was sent to Dr. Snyder for identification purpose. In an inoculation experiment made later by Mr. Tsai, six plants of the Luzon Chiau variety were inoculated with the *Fusarium*, and one developed symptoms. However, since these test plants originally came from a disease area, Mr. Tsai did not attach much significance to his results. Neither was a definite answer received from Dr. Snyder as to the identity of the *Fusarium* culture in question.

In February, 1970 banana plants with leaf yellowing symptoms were seen in the Chiatung area and were thought to be the result of cold injury by the field workers. Mr. C. K. Chu of Chiayi AES was the first person to suggest its possible identity to Panama disease. Greater concern was caused in this case for it was found, for the first time, that the disease attacked the main commercial variety and invaded a main banana growing area. By early March when a field observation was conducted by several plant pathologists, including Dr. H. J. Su, Dr. H. Y. Liu and myself, the disease was observed to have completely ruined a banana plantation in Chiatung originally having 270 plants planted in March 1969. Another plantation about one mile away was also affected with a high disease incidence. The characteristic vascular syndrome appeared in the rhyzome and pseudostem of the diseased plants. Upon suggestion by the plant pathologists group, a meeting was called on March 19, 1970 presided over by Commissioner H. S. Chang to discuss emergency measures for disease control. As a consequence of this meeting, a small working group was designated to formulate an emergency control program the details of which will be described in later sections.

Symptoms

On both Peichiau and Luzon Chiau varieties, the most conspicuous symptoms of banana wilt are progressive yellowing from the lower leaves to the upper. The brilliantly yellowed leaves are characteristic and can be easily identified. Pseudostem splitting is not common though it can occasionally be observed. When cut across, the rhizome of the diseased plants shows various degree of color changes in the vascular tissues. Yellowish brown to red dots either scatter throughout the cut surface or may more frequently be localized to certain areas in the margin. Numerous purplish pin-head size spots can also be seen on the cut leaf sheaths at early stages of infection. In later stages probably accompanied by secondary infection, these spots may collapse to form large dark-red patches. In a Chiatung banana plantation, most of the plants showed typical leaf yellowing some of which had already been removed. The remaining symptomless few had characteristic vascular changes in the pseudostem when cut.

Many of the main roots of the diseased plants had a reddish decaying stele. This, however, is less specific for identification purpose than the vascular discoloration in a rhizome or pseudostem.

Present Status of the Disease

It is not known since when the disease has occurred in Taiwan. Information from banana growers indicates that as early as 1967 a few diseased plants were observed sporadically in the Linpien and Chiatung areas. Apparently, the number of affected plants was gradually increased the next two years during which several plantations were rendered unprofitable for growing bananas. According to a survey made in April, 1970, the disease was found in 98 plantations with a combined area of 25.41 ha. A total of 5,536 banana plants were either seen with unequivocal symptoms or had been destroyed. Although most of the affected plantations had a relatively low disease incidence, many suffered considerable damage. The following two tables summarize the present status of the disease in the Kaohsiung-Pingtung banana growing area.

Table 1. Present status of banana wilt as recorded by localities

Locality	Diseased plantations		Total plant number	No. of affected plants
	Number	Combined acreage (ha)		
Chiatung	59	17.19	32,811	3,854
Linpien	38	5.42	9,117	1,672
Nanchou	1	2.80	5,445	10
Total	98	25.41	47,373	5,536

Note: Data provided by the Kaohsiung Fruit Marketing Cooperative, collected on or before April 8, 1970.

Table 2. Present status of banana wilt as analyzed by levels of disease incidence in the affected plantations

Level of incidence	No. of diseased plantations	Total diseased area (ha)	Total plant number	No. of affected plants
80—100%	4	0.53	970	900
60—80	9	1.11	1,976	1,311
40—60	7	1.08	1,922	862
20—40	12	1.95	3,753	1,027
15—20	4	0.65	1,254	220
10—15	10	2.39	4,508	584
5—10	13	2.88	5,350	364
5	39	14.82	27,640	268
Total	98	25.41	47,373	5,536

Note: Data provided by the Kaohsiung Fruit Marketing Cooperative, collected on or before April 8, 1970.

Some Notes on Disease Ecology and Epidemiology

Banana wilt is caused by *Fusarium oxysporum f. cubense.* Although not considered a normal soil inhabitant, the fungus can survive in the soil for years. The longivity and level of population of the fungus are largely determined by such soil environmental factors as pH, soil types, oxygen supply in the soil, etc. A pH of about six favors population increase of the fungus if other factors are also favorable. Deficiency in oxygen as may be created by flooding or poor drainage results in rapid population decline and eventual elimination of the fungus from the soil. This had once been the practice in Panama disease control in Honduras, Panama and other areas in South and Central Americas.

The various spore types of *F. oxysporum f. cubense* can be disseminated by air, water and other means. But the actual spread of the disease is generally believed to be mainly the result of planting infected suckers which may later become new sources of infection. A patch of diseased plants radiating from an old infection is commonly observed in the field. High level of fungus population is built up in the diseased plantations when infected plant tissues are left on the ground or mixed with the soil.

It is not known how the fungus initiates infection. No advanced infection can be induced in wounded or unwounded rhizomes by inoculation with heavy inoculum. Natural infection is believed to occur when lateral rootlets are in contact with the fungus. For successful inoculation, a high population level of the fungus is believed essential. After entering the rootlets, the fungus first reaches the vascular tissues and gradually makes its way into the main roots. Eventually, it passes the junction to reach the rhizome from where further penetration into the leaf sheaths occurs. The ease with which the fungus causes infection in the lateral roots and invades the rhizome is determined by plant resistance. Differences in responses to infection have been observed between resistant and susceptible varieties. Spread of the disease is less rapid and rhizome infection is rare or less extensive in the resistant varieties. Again, most infected plants of resistant varieties show no external symptoms despite the presence of discolored vasculars in the rhizomes or pseudostems.

A single spore has been proved insufficient in initiating an infection in either resistant or susceptible varieties.

Emergency Control Measures

The presence of 25-50% of diseased plants in a plantation is considered an epidemic according to Stover (1962). By this criterion, wilt epidemic had already occurred in the Chiatung area affecting some 30 small plantations this spring in spite of the fact that the variety grown was generally considered highly resistant. Accordingly, some emergency control measures have been proposed to be enforced. In formulating the emergency control program in mid-April, the following assumptions were made:

1. The disease in question is identical to banana wilt which is caused by *Fusarium oxysporum f. cubense.*
2. The disease has been so far limited to the Kaohsiung-Pingtung area where field infection was observed.
3. Extensive sucker movement did not occur prior to enforcement of the emergency measures.

It is based on the above assumptions that the program emphasizes the destruction of diseased plants and prohibition of the movement of disease materials. Measures to be taken under the program include the following:

1. All suckers in the affected plantations are to be destroyed by treatment with mineral oil and movement of suckers from the diseased to other areas is prohibited.
2. No movement of plant materials such as banana pseudostems and rhizomes from the affected plantations is permitted.

*3. Planting of bananas in the affected plantations as well as in the nearby areas within a distance determined by topography is to be discontinued for one to two years. Whenever possible, the devastated land is to be turned into paddy field.

4. All plant materials, diseased or healthy, from the affected plantations are to be destroyed not later than late July. The soil is to be treated with calcium cyanamide at the rate of 1 ton per hectare prior to cultivation of succeeding crops.

These measures can be practical and effective only if, by the time of their enforcement, the disease is still limited in occurrence and spread has not been extensive. To what degree of thoroughness these measures are enforced will be another factor to which success or failure of the program is to be attributed.

* This part of the control program is later modified to allow continued cultivation of bananas in areas free from infection adjacent to diseased plantations.

Speculation on the Disease Origin in Taiwan

The disease in question was not given adequate study in Taiwan when emergency control measures were to be formulated. Although field symptoms strongly suggested its being identical to banana wilt, definite proof was obtained only recently when a second batch of *Fusarium* isolations sent on April 8 to Dr. William Snyder were identified to be *F. oxysporum f. cubense.* Identification as to pathogenic race would not be possible until a thorough comparison of varietal reactions is made. To race 1 which is world wide in distribution, varieties of the Cavendish type in which the commercial variety of Taiwan, Peichiau, may be included are generally believed resistant. Banana plants of this variety group often show no external symptoms on infection with the race. Race 2 is rather limited in its distribution and of less economic importance despite its being more virulent on some Cavendish varieties than race 1. The outbreak of an epidemic in a number of banana plantations in Chiatung and its vicinity is, therefore, somewhat puzzling if either of the two races is involved. Regarding the origin of the wilt fungus in Taiwan, three possible hypotheses may be offered at this moment:

1. The causal fungus was not present in Taiwan, or at least not in the main banana growing areas, previously, but was introduced in recent years, possibly in association with introduced banana seedlings or other non-related plants. Since sporadic occurrence of the disease was observed by the growers in 1967, introduction of the causal fungus must have occurred before that date. For this hypothesis to be acceptable, disease spread should be traceable to one single or a few isolated sources of original infection. Distribution of the fungus at present is not yet extensive. This hypothesis makes no presumption on the race involved, but requires a certain degree of susceptibility in the commercial variety Peichiau.

2. The fungus has been present in Taiwan's soil for long, but because the commercially grown banana variety is highly resistant, it caused no apparent damage to arouse much concern in the past. This is a more probable situation if race 1 is the pathogen. However, before this hypothesis can be accepted, sound explanation should be given to the present epidemic of wilt in the Chiatung area on the basis excluding varietal susceptibility. Finding the same fungus widespread in areas free from recognizable disease symptoms would further substantiate this hypothesis.

3. The fungus involved in the presently observed wilt epidemic in Chiatung belongs to a new race virulent on the main variety Peichiau of Taiwan. Emergence of this race may be a result of mutation of existing less virulent fungus or simply a consequence of new introduction. For proof, the fungus should be demonstrated experimentally to possess a pathogenecity pattern which is different from the known races.

With the evidence mentioned above, it is beyond any doubt that banana does occur in Taiwan. Although it is too early to speculate on the damage that this disease may possibly do to Taiwan's banana industry in the future, one thing seems obvious and that is the degree of disease resistance in the commercial variety Peichiau is inadequate to ensure its profitable cultivation under circumstances existing in some of the banana plantations in Chiatung and the nearby areas. This simple reason should justify extensive research effort on the subject.

RICE INSECT PROBLEMS IN TAIWAN

David F. Yen

Annual Loss of Rice Caused by Insect Pests

The modern way of agricultural production has helped create many plant troubles. Experience has shown that the more highly developed and intensive agriculture becomes, the more complicated are its problems resulting in more plant troubles. Hence the people who live on farms take insect damage for granted as part of the normal and principal hazard of crop production. However, with modern operations, the difference between a 5 and 30% loss can easily represent the difference between a gainful and an unprofitable farming operation. When faced with the prospect of loss from insect damage, the modern producer needs to know whether the potential loss will be larger than the cost of control and the approximate difference. Better methods for determining insect loss and more accurate estimates of probable insect damage in specific situations are thus needed.

In Taiwan, more than 20 species of insects attacking rice plant have been recorded. About a dozen of the existing species are believed capable of causing substantial loss to rice production, even their importance varying considerably.

According to a report published by the Mountain Agricultural Resources Development Bureau, PDAF in 1969 (Document No. Shan-Nung 12747), an annual loss of rice caused by insect pest attacks was, in monetary terms, about NT$1,128,376,500 or 8% of the total production. We should keep in mind, however, that this figure is just an estimate based on data collected from different townships, and that damage tends to vary greatly from field to field, place to place and year to year. Even though the local peasant farmers put nearly NT$300,000,000 worth of sprays and dusts on their paddy crops annually, control measures for many pests are neither adequate nor practical, and huge losses are still suffered from pests for which control recommendations exist. This figure presents a challenge to those who are responsible for improving the methods of insect pest control.

The Most Serious Insect Species and Their Occurrence

Based on island-wide surveys and data collected from different district agricultural improvement stations, the most serious and/or the key species attacking the rice plant are as follows:

Striped borer	*Chilo suppressalis*
Paddy borer	*Tryporyza incertulas*
Grass leaf roller	*Cnaphalocrocis medinalis*
Rice leaf roller	*Parnara colaca*
Rice swarming caterpillar	*Sesamia inferens*
Green leaf hopper	*Nephotettix apicalis*
	Nephotettix cincticeps
Brown plant hopper	*Nilaparvata lugens*
White-back plant hopper	*Sogattella furcifere*
Leaf beetle	*Oulema oryzae*
Rice plant weevil	*Echinocnemus bipunctatus*
Rice bug	*Scotinophora lurida*

Difference of occurrence in terms of infested acreage or hectares being infested is present between the two rice crops planted and harvested every year. The attached Figs. 1 and 2 show the occurrence of the listed species in the period from 1963 to 1969.

In Figs. 1 and 2 we find that, during the past seven years, some species such as the paddy borer, *Tryporyza incertulas*, the grass leaf roller, *Cnaphalocrocis medinalis*, and the rice bug, *Scotinophora lurida* have been checked to a negligible degree by the application of conventional spray or dust. Meanwhile, species such as the rice stem borer, *Chilo suppressalis*, on the second crop, the rice swarming caterpillar, *Sesamia inferens*, on the first crop, the leaf hoppers, *Nephatettix apicalis* and *N. cincticeps* on both first and second crops, the rice leaf roller, *Parnara colaca*, the rice plant weevil, *Echinocnemus bipunctatus* on the first crop, and the rice thrips, *Thrips oryzae* on the first crop occurred in higher population and infested larger acreage than before. It is considered that the reasons why this was so might be due to: 1) the improper application of insecticides which stimulated the insects into developing resistant individuals or strains; 2) the natural enemies of the target pest species have been wiped out by the application of insecticides; 3) modification or changing of cropping systems of crop varieties; and 4) non-standardization of the locally produced chemicals.

Work on Rice Insect Control to be Done

Past experiences have demonstrated the tremendous possibilities of using chemicals for insect control as well as the pitfalls resulting from their indiscriminate use. Even now, the commonly used insecticides represent only a few chemical groups, and it seems certain that other groups will be discovered that will provide greater latitude in selection and use. Meanwhile, skill in the formulation and application of available insecticides continues to grow.

Sole reliance on chemicals for pest control has many side-effects such as selection of resistance to insecticides in pest population; resurgence of treated populations; outbreak of secondary pests; residues, hazards and legal complications and destruction of beneficial species including parasites, predators, pathogens, pollinating insects, etc.

Insecticide is not a panacea. The decision to employ insecticides for the control of insects depends on an overall assessment of each problem. However, one of the guiding principles in such decision-making is that insecticide treatments are justified only when the expected loss without treatment exceeds the cost of treatment. It is based on this line of reasoning that no insecticide application is considered necessary for the control of the rice bug, hispa beetle and rice borers on this island.

The ecological factors affecting insect populations are of primary importance to planning or improving control programs. All available knowledge about the biotic and abiotic characteristics of the environment affecting the pest should be used in weaving a pattern of insect control for a specific pest in a certain area. Therefore, a control program of rice insect in Taiwan, it is hoped, will include the following items to be conducted in the coming 3-5 years:

1. Survey or inspection of the insect fauna (including insect pests, parasites and predators) and the micro-flora (especially micro-pathogens of insect pests) in the paddy field.

2. Investigation of the relationship of the occurrence of insects, either key pests, secondary pests or occasional pests, to current farm practices.

3. Cooperating with agronomists in the selection or breeding of resistant varieties to the major homopterous pests and lepidopterous borers.

4. Screening out low toxic and highly selective chemicals and/or formulations for integration with other feasible control measures.

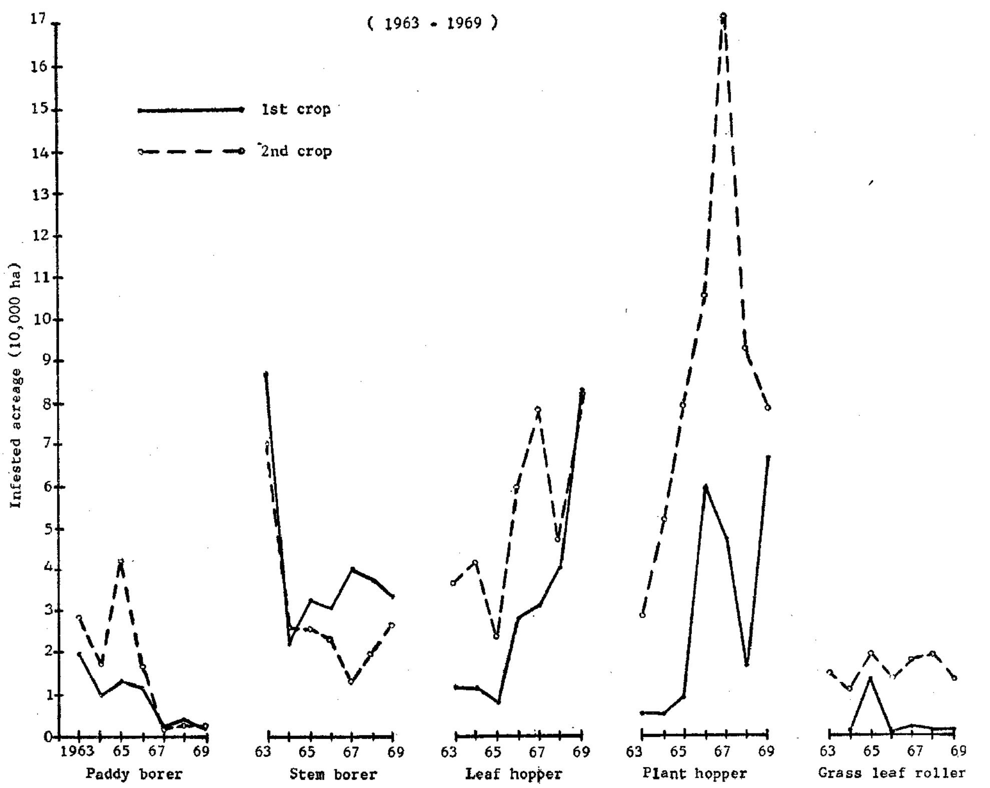


Fig. 1. Rice acreage infested by various insect pests in Taiwan (1963-1969)

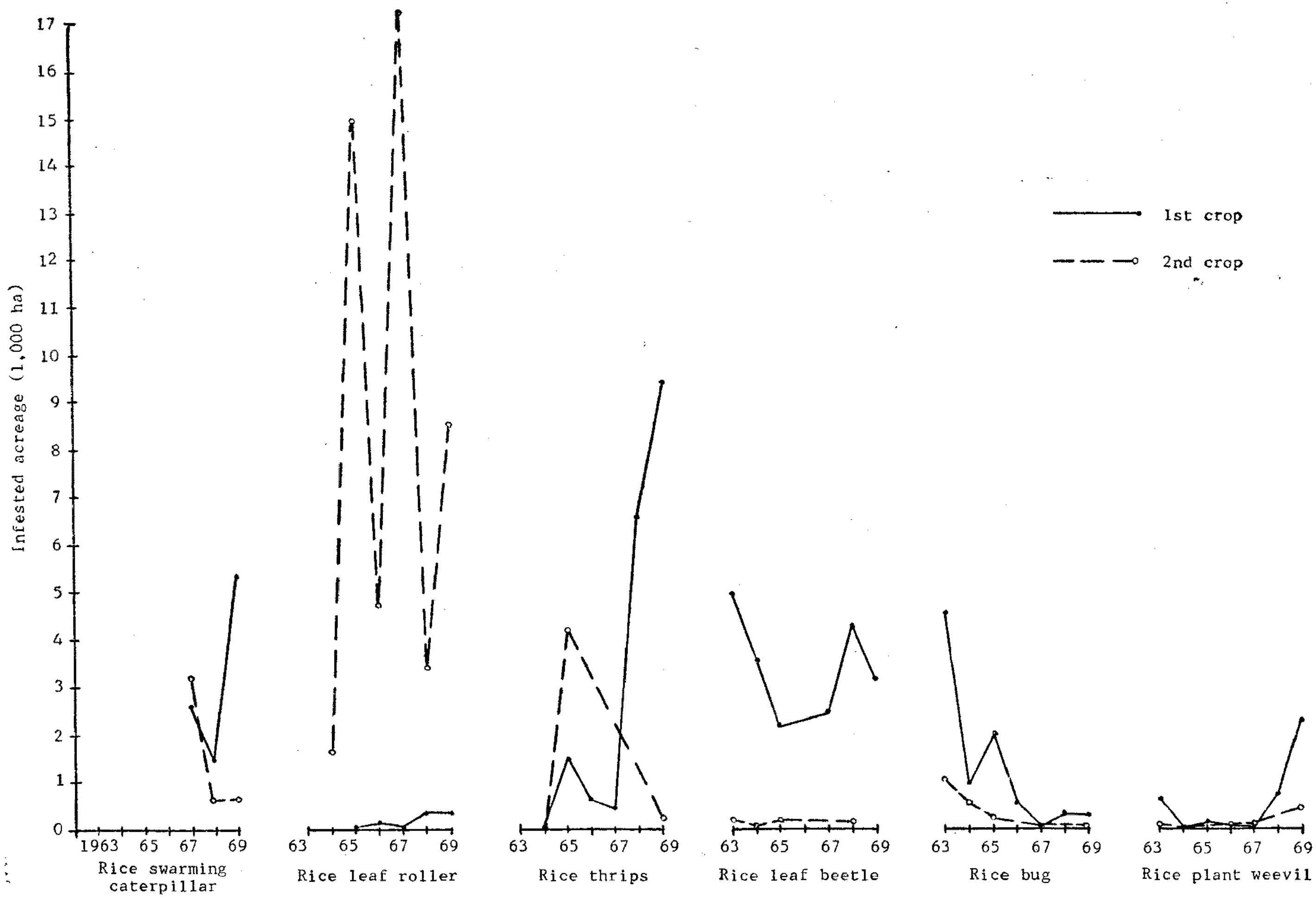


Fig. 2. Rice acreage infested by various insect pests in Taiwan (1963-1969)

A NEW APPROACH TO THE EXISTING SEED MULTIPLICATION PROGRAM IN TAIWAN

Cheng-I Lin

In 1960, a modern seed multiplication program was officially launched in Taiwan, beginning with rice and then extending to other field crops.

Since then, agricultural organizations dealing with crop production have been benefited from this system in increasing crop production, while the seed production, certification and distribution agencies are content in following the same program year after year.

Recently an island-wide survey was made to find out the actual situation of both extension seed production and exchange of certified seeds among farmers, besides conducting frequent follow-up checks on seed production and certification. Meantime questionnaires were sent to farmers to canvass their opinions toward this program. Results thus obtained were far from encouraging. So it is time to make a thorough re-evaluation of the whole program in an attempt to bring it up-to-date.

Shortcomings in Seed Multiplication and Certification

A. Seed multiplication

Approximately 3,500 seed farms (Tables la & lb) covering 2,400 hectares of land are producing about 6,000 m. t. of crop seeds under the seed multiplication program at present. The size of each seed farm, however, is too small for economical efficient seed production, and the wide distribution of these small farms makes the situation even worse.

Taking rice seed as an example, about 1,700 seed farms are scattered over mone than 300 townships, except those in the high Central Mountain area. The following are the findings:

a) About half of the township seed farms produce less than the average yield of the respective counties. In fact, much smaller acreage will be sufficient to produce the same amount of seeds needed for exchange if seed multiplication is carried out only in those townships where yields are higher than the average of the respective counties.

b) Extension seeds are still being produced in townships where rice production in the 2nd crop season remains unstable.

c) Often seed farms are established in very remote townships producing only very limited amount of seeds.

d) Even within the same township, all the extension seed farms are widely distributed.

Therefore, it is impossible for the limited number of seed technicians in each county (usually one in each county)

Table 1a. Number of foundation (F), stock (S) and extension (E) seed farms of major field crops in 1967

DAIS or County	Rice			Sweet potato			Peanut			Soybean			Wheat		
	F	S	E	F	S	E	F	S	E	F	S	E	F	S	E
Taipei DAIS	4	0	0	3	0	0	1	0	0	2	0	0	0	0	0
Taipei	0	6	62	0	2	20	0	0	0	0	0	0	0	0	0
Taoyuan	0	7	121	0	4	29	0	2	4	0	0	0	0	0	0
Hsinchu DAIS	5	0	0	4	0	0	1	0	0	1	0	0	0	0	0
Hsinchu	0	4	68	0	4	48	0	3	20	0	0	0	0	0	0
Miaoli	0	5	116	0	4	27	0	8	35	0	8	15	0	3	55
Taichung DAIS	7	0	0	2	0	0	1	0	0	2	0	0	3	0	0
Taichung	0	10	191	0	1	9	0	5	50	0	0	0	0	16	308
Changhua	0	7	99	0	1	30	0	5	55	0	3	5	0	4	40
Nantou	0	5	66	0	1	25	0	0	0	0	0	0	0	0	0
Yunlin	0	5	184	0	1	35	0	14	155	0	2	5	0	2	10
Chiayi	0	4	88	0	1	30	0	7	90	0	2	10	0	0	0
Tainan DAIS	3	0	0	2	0	0	2	0	0	2	0	0	2	0	0
Tainan	0	7	191	0	4	30	0	8	50	0	3	10	0	0	0
Kaohsiung DAIS	5	0	0	3	0	0	1	0	0	3	0	0	0	0	0
Kaohsiung	0	8	171	0	4	73	0	2	4	0	2	30	0	0	0
Pingtung	0	6	190	0	10	6	0	2	5	0	4	65	0	0	0
Taitung DAIS	4	0	0	4	0	0	1	0	0	6	0	0	0	0	0
Taitung	0	6	110	0	6	23	0	1	26	0	6	23	0	0	0
Hualien DAIS	3	0	0	2	0	0	1	0	0	1	0	0	0	0	0
Hualien	0	6	33	0	2	25	0	1	10	0	1	15	0	0	0
Total	31	86	1,690	20	45	410	8	58	504	17	31	178	5	25	413
	1,807			475			570			226			443		
	3,521														

to take care of the seed farms properly. The same is true of the limited number of field inspectors of PDAF (five in total) who cannot make thorough field inspections to ensure genetic purity of seeds.

B. *Seed certification*

Because of the widely distributed township seed farms and the impossibility for PDAF field inspectors to make thorough field inspections as only a very small number of seed farms is inspected by them (Table 2), all the extension seed farms have to be inspected by seed technicians of the local governments with the following results:

a) The seed technicians who serve as inspectors are also seed producers.

b) The number of seed technicians in each local government is not sufficient for adequate inspection.

Therefore, the results of inspection are not dependable as illustrated in Fig. 1.

The current practice of having all the PDAF field inspectors stationed in one place, at the Seed Testing Laboratory in Taichung, certainly needs reexamination.

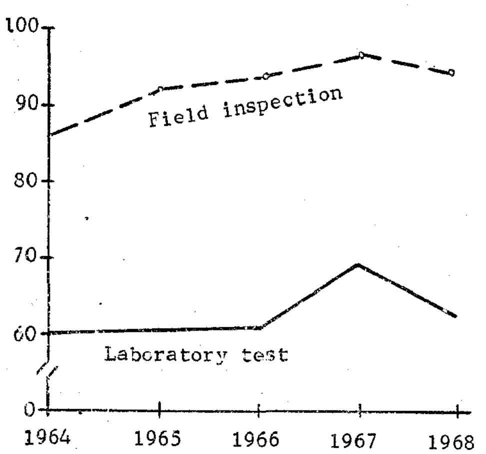
Table 1b. Number of foundation (F), stock (S) and extension (E) seed farms of four vegetable crops in 1967

DAIS or County	Chinese kale			Radish			Edible rape			Cauliflower		
	F	S	E	F	S	E	F	S	E	F	S	E
Taipei DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Taipei	0	0	0	0	0	0	0	0	0	0	0	0
Taoyuan	0	0	0	0	0	0	0	0	0	0	0	0
Hsinchu DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Hsinchu	0	0	0	0	0	0	0	0	0	0	0	4
Miaoli	0	0	0	0	0	0	0	0	0	0	0	0
Taichung DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Taichung	0	0	0	0	0	174	0	0	0	0	0	0
Changhua	0	0	31	0	0	0	0	0	9	0	0	0
Nantou	0	0	0	0	0	0	0	0	0	0	0	0
Yunlin	0	0	73	0	0	26	0	0	11	0	0	4
Chiayi	0	0	179	0	0	89	0	0	0	0	0	0
Tainan DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Tainan	0	0	11	0	0	0	0	0	0	0	0	18
Kaohsiung DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Kaohsiung	0	0	0	0	0	0	0	0	0	0	0	1
Pingtung	0	0	0	0	0	0	0	0	0	0	0	0
Taitung DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Taitung	0	0	0	0	0	0	0	0	0	0	0	0
Hualien DAIS	0	0	0	0	0	0	0	0	0	0	0	0
Hualien	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	294	0	0	289	0	0	20	0	0	27
	294			289			20			27		
	630											

Table 2. Annual workload of PDAF field inspectors in Taiwan (1968)

Crop	Number of seed farms			Acreage of seed farms	
	Total	Inspected	%	Total (ha)	Inspected (ha)
Rice	1,675	96	6	1,627	39
Sweet potato	451	54	11	30	4
Peanut	556	63	11	355	35
Soybean	181	31	17	180	8
Wheat	444	31	7	255	8
Vegetables	630	630	100	223	223
Others	30	30	100		
Total	3,497	905	26	2,420	317

Since more than one variety of each crop is included in seed multiplication and several kinds of crop seeds are produced in different classes of seed farms (Tables la & lb) of each county in different growing seasons, it is usually the case that an inspector at Taichung, at the request of a local government or a district agricultural improvement station, would spend several hours on the way to the seed farm where he may conduct inspection for only about one hour and then take the long trip back to Taichung. Not only does efficiency of the inspection remain low, but also the field inspectors themselves are never given the chance to get well acquainted with the local conditions in the area, let alone render adequate assistance to seed farmers as well as local governments.



Percentage of qualified seed farms and/or seed samples (%)

Fig. 1. Results of rice seed certification on extension seed farms

As shown in Fig. 1, the results of field inspection by local technicians looked quite good. However, when seed samples from those qualified seed farms were submitted for seed testing in the PDAF Seed Testing Laboratory, the results were poor. According to the Laboratory, the chief factor causing this phenomenon was the admixture of foreign varieties. This clearly indicates that the accuracy of the inspection made by local governments is highly questionable.

Proposed Solutions

To rectify the above shortcomings in the present system, a centralized seed production method may be adopted. The salient features of this method are briefly stated below.

A. Seed sections to be established in each county

According to the geographic positions and crop planting acreage of the respective townships, each county can be divided into three seed sections.

B. Seed supply townships to be created in each county:

One township per seed section will be chosen as the seed supply township selected on the basis of its high yield and convenience of transportation to supply the needed seeds to other townships within the section.

By following this method, about 5,500 m.t. of seeds can be produced from 1,500 ha of seed farms in 47 townships compared with the previous 5,200 m.t. from 1,740 ha in more than 300 townships under the present system.

C. Separate stations for PDAF field inspectors

More efficient work can be done if the five specialized field inspectors of PDAF are stationed in five separate agricultural districts to assume the following responsibilities:

a) To assist the local government in selecting seed multiplication sites and farmers.

b) To help the local government do better work in field management, roguing, etc. of seed farms.

c) To serve as liaison officers of the related agencies within each district.

d) To conduct field inspections of all the seed farms in addition to sampling and sealing of seed products.

e) To supervise the work done by the licensed field inspectors.

f) To make periodic surveys on seed production.

g) To enforce seed marketing regulations promulgated by the government.

D. Assistance to be rendered at all times to licensed field inspectors

The workload of the PDAF field inspectors is undoubtedly too heavy. That was the reason why licensed field inspectors were trained in the past two years to assist the PDAF field inspectors. There are altogether 35 licensed field inspectors to conduct rice seed inspections and 15 for vegetable seed inspections. Each PDAF field inspector has to carry out the above-mentioned responsibilities with the assistance of approximately 7 to 10 licensed field inspectors.

In this way, better seeds can be produced through centralized seed production; seed certification can be efficiently made by PDAF personnel; and seed exchange can be efficiently and satisfactorily conducted.

Future Endeavor

A basis of 60 kg/ha of seeds is now used for calculating the amount of seeds needed, planning the seed multiplication program and meeting the requirements of seed exchange. However, 40 kg of seeds will be enough for planting one hectare if seeds of better quality can be supplied. Furthermore, since the size of the average rice field per farmer is less than one hectare, it does not seem reasonable to ask farmers to exchange seeds on a 60-kg basis. As one seed exchange per six crops is now practised in Taiwan, even smaller amounts of seeds can be sufficient for planting individual fields in the next crop season. Therefore, the exchange basis of 60 kg/ha is open to question. If the basis of 20 kg/ha is used, then the whole seed production can be reduced by two-thirds, thus enabling the township with the highest seed yield to supply the entire needs of the whole county.

With the reduction in extension seeds, the amount of foundation seeds and stock seeds can also be reduced in proportion. Then and then only will it be possible to keep seeds in cold storage for future use instead of annual plantings.

If the same procedures are applied to the production of other crop seeds, the work of seed multiplication, certification and distribution will be greatly simplified. As can be seen in Tables 1a and 1b, Yunlin County is capable of producing most crop and vegetable seeds, so it is our hope that a mammoth seed supply center can be set up in this area to supply seeds to the whole island on commercial basis in the future.

VEGETABLE SEEDS

Cheng-I Lin

Vegetable Seed Production for Domestic Consumption

The planted acreage of vegetable crops in Taiwan has been around 110,000 ha with an annual increase of about 4% in the past four years, for more and more vegetables are in demand to supplement the nutritional intake of the general populace. As a result, the amount of vegetable seeds needed for planting has been increasing steadily. Based on the prevailing planted acreage (112,886 ha) and the recommended sowing rate of respective vegetable crops, it was estimated that approximately 655 m.t. of seeds and 3,800 m.t. of vegetative seed units were needed in the calendar year of 1966. However, the actual amount of seeds used would be much more than what was given above when such factors as seed purity, germination capacity and germination failure in the field are taken into consideration.

Table 1. Estimated annual consumption of vegetable seeds (1966) and amounts of seeds sold to farmers by seed retailers in Taiwan (1965)

Category of vegetable crops	Amount of seeds required for planting			Amount of seeds sold commercially		
	Seed		Vegetative unit	Seed		Vegetative unit
	kg	(%)	kg	kg	(%)	kg
Leaf vegetables	137,289	(21)	0	359,852	(51)	0
Stem vegetables	50,673	(8)	3,796,396	13,793	(1)	681,725
Root vegetables	70,603	(11)	0	147,005	(21)	0
Flower/fruit vegetables	35,068	(5)	0	14,924	(2)	0
Legumes	361,245	(55)	0	171,551	(24)	0
Total:	654,878	(100)	3,796,396	707,130	(100)	681,725

In Table 1, the estimated seed requirements are given under different categories of vegetable crops.

A survey conducted in 1965 revealed that approximately 707 m.t. of vegetable seeds and 681 m.t. of vegetative seed units were sold to the local farmers through seed retailers. (Table 1)

By comparing the seeds needed and sold in Table 1, it is apparent that the vegetable farmers in Taiwan obtain most of their seeds of leaf and root vegetables from the local market, while they use their own reserved seeds largely for growing stem vegetables, fruit vegetables and legumes.

The ratios of the amount sold to the required seeds of leaf and root vegetables are 2.6 and 2.1, respectively. If the average rate of 2.4 is taken as the common ratio, then the actual amount of vegetable seeds used in 1966 will be approximately 1,570 m.t. If so, some 870 m.t. of seeds (55%) for 1966 consumption (1,570 m.t.) came from farmers' reserved seeds, while the remaining 45% from the seed markets.

Seed Export and Import

There was practically no seed exported 15 years ago. But since then both the kinds of crop seeds produced and the amount exported have been increasing greatly, though subjected to yearly fluctuations in the early development period. The expansion of seed export has been especially notable during the past 4 years as shown in Table 2 and Fig. 1.

According to Table 2, about 280 metric tons of vegetable seeds excluding vegetative seed units were exported to foreign countries in 1968. Of this amount, leaf vegetable and root vegetable were the two leading crop categories.

Table 2. Vegetable Seed Exports of Taiwan in 1965-68

Category of vegetable crops	1965		1966*		1967		1968**	
	kg	(%)	kg	(%)	kg	(%)	kg	(%)
Leaf vegetable	69,804	(100)	43,021	(62)	93,972	(134)	201,175	(288)
Stem vegetable	0		0		0		0	
Root vegetable	8,758	(100)	32,384	(370)	58,551	(669)	60,347	(690)
Fruit/flower vegetable	2,042	(100)	2,291	(112)	8,033	(393)	9,964	(492)
Legumes	11,448	(100)	4,277	(37)	17,281	(151)	20,627	(180)
Total:	92,052	(100)	81,973	(90)	177,897	(193)	292,113	(300)

* Export was affected by a hot spell during the crop season of cruciferous vegetables and pea.
** Figures quoted are not complete.

No figures were given for stem vegetables in Table 2. Under this category garlic bulb which can be used as a commodity or planting material was predominant. Presumably a considerable amount of garlic bulb exported as a commodity item (about 1,200 m. t. annually) had also been used for planting purpose.

The import of vegetable seeds has remained fairly stable in the past four years, particularly the leaf and root vegetables which were constant at about 53 m. t. and 12 m. t. respectively, while fluctuations were observed in stem vegetables and legumes. It is the fruit vegetables, however, which have shown constant increase in import volume. Approximately 80 m. t. of seeds and 600 m. t. of vegetative seed units were imported annually.

Fig. 2 shows the relationship between planting acreage, seed export and import of tomato, cauliflower, water-

Table 3. Vegetable Seed Imports of Taiwan in 1965-68

Category of vegetable crops	1965 kg	1966 kg	1967 kg	1968 kg
Leaf vegetables	54,849	62,973*	52,900	53,636
Stem vegetables	11,313	5,659	4,270	8,524
Root vegetables	12,589	12,337	10,506	12,766
Fruit/flower vegetables	247	456	1,587	2,753
Legumes	715	17,342**	3,567	79
Total:	79,712	98,767	72,830	77,758
Stem vegetables, vegetative seed units	360,970	673,452	685,828	575,537

* Increased import due to poor seed production in the previous crop year.
** Mostly pea.

melon and cabbage crops.

To sum up the foregoing estimates, the annual seed production of vegetable crops in Taiwan would be:

Seed production for domestic consumption:

Self-reserved	870 m. t.
For local market	700 m. t.
For export	270 m. t.
	1,840 m. t.
Minus import	80 m. t.
Total production:	1,760 m. t.

Hybrid Vegetable Seeds and Flower seeds

Another new development of vegetable seed production in Taiwan is hybrid vegetable seed production for export, which is progressing quite rapidly. Kinds of vegetable seeds included are mostly cucumber, tomato, pepper, eggplant and watermelon. Fig. 3 shows the development tendency.

The same is the case with flower seed production which is developing rapidly to meet the increased demand for both export and domestic use. Its development tendency is shown in Fig. 4.

Conclusion

Most of the vegetable seeds are produced in the winter dry season in central and southern Taiwan. Ample sunshine, moderate winter temperature, well-established irrigation facilities, hard-working and skilled farmers and relatively low labor wages are factors favorable to vegetable seed production in Taiwan.

While the seed production of food and other major field crops depends on the Government for seed multiplication, certification and distribution, the production and marketing of vegetable and flower seeds has all the time been a commercial enterprise.

However, the Government has offered its help to this newly developed industry toward reaching the goal of "growing and selling high quality seeds" and meantime JCRR has been rendering necessary technical and financial assistance.

Judging from the past development tendency, the prospects for large-scale production of vegetable and flower seeds in Taiwan are indeed very promising. However, in view of the importance of overall seed production and strong competition prevailing in the world seed market, efforts have to be made to remove all the bottlenecks that stand in the way to the production of high quality seeds.

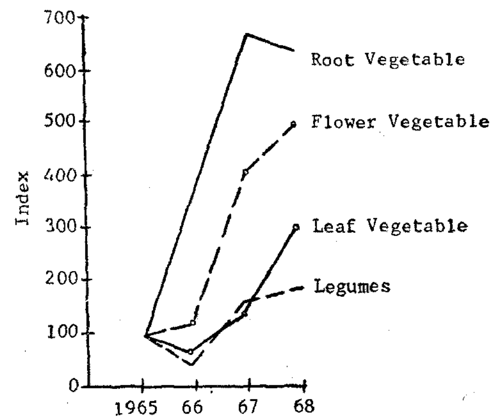


Fig. 1. Trend of Vegetable Seed Export

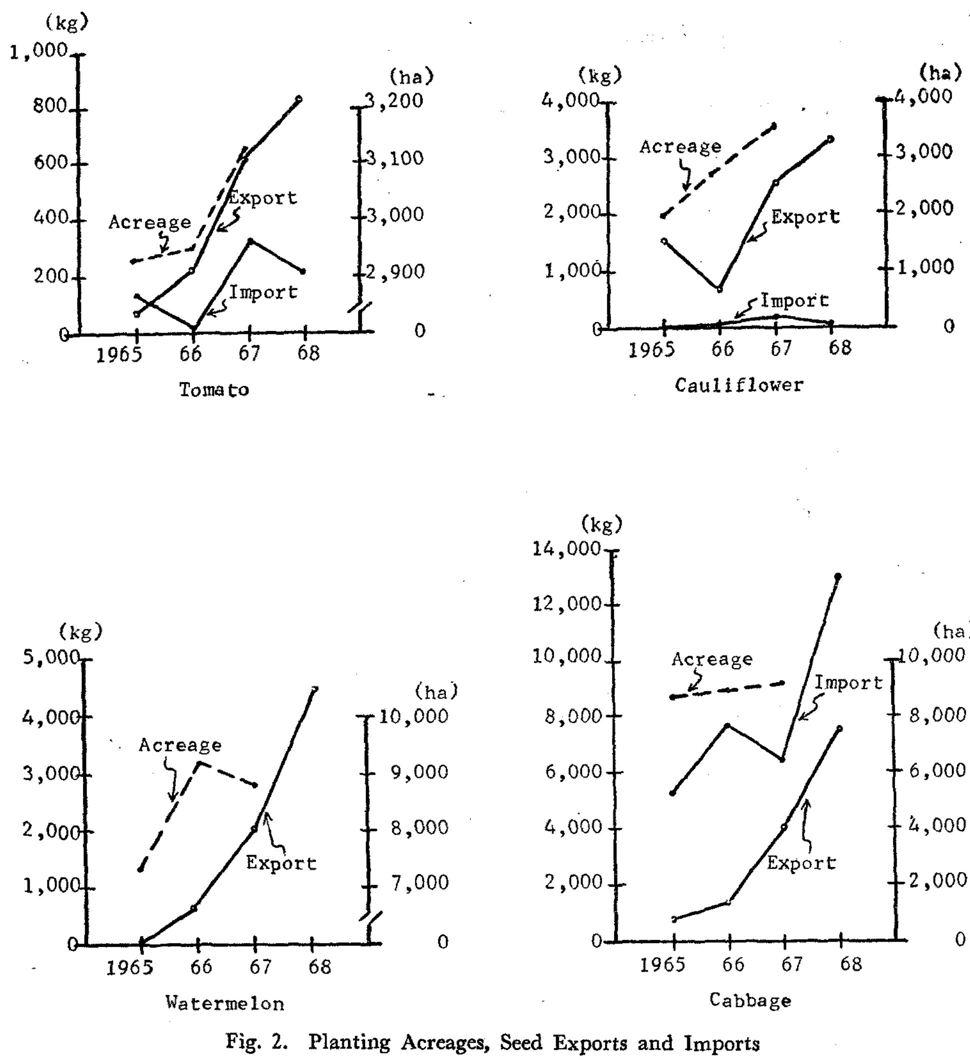


Fig. 2. Planting Acreages, Seed Exports and Imports of Four Kinds of Vegetables

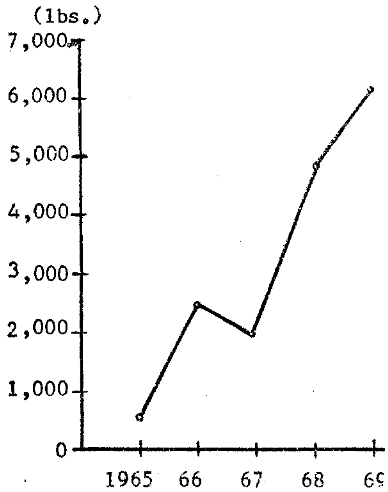


Fig. 3. Hybrid Vegetable Seeds Exported by a Leading Private Company

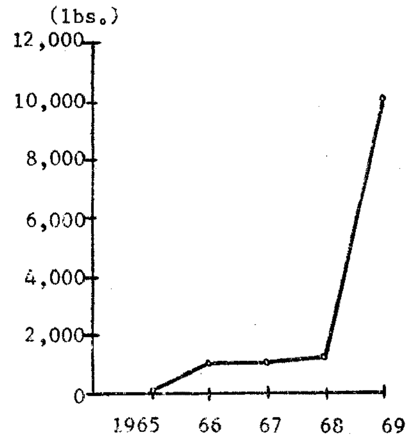


Fig. 4. Flower Seeds Exported by a Private Company

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