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JCRR

THINKING AND DOING FOR BETTER CROP PRODUCTION

— PID Activities —

(July 1968—June 1969)

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PLANT INDUSTRY DIVISION
JOINT COMMISSION ON RURAL RECONSTRUCTION

PREFACE

The Joint Commission on Rural Reconstruction (JCRR) has been playing an active role in Taiwan's agricultural development, which today continues to occupy an important position in our national economy.

The success of the JCRR program can be attributed, to a large extent, to the excellent coordination and cooperation not only between JCRR and the various sponsoring agencies, but also among the individual specialists of JCRR itself. I am glad to note that my colleagues in the Plant Industry Division have always worked harmoniously in their common effort to increase crop production in Taiwan.

This volume reviews the work of PID. It represents the thinking of our specialists on the problems and difficulties they have had to contend with and the steps that are necessary to deal with them effectively. I hope that the information will contribute to a better understanding of the overall crop improvement program of Taiwan.

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Chief
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Taipei, Taiwan
Republic of China

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THE FUTURE TREND AND PROPOSAL FOR INCREASING RICE PRODUCTION IN TAIWAN

Cheng-Hwa Huang

Since the implementation of the first 4th-year Economic Development Plan, rice production in Taiwan has been increased from 1,641,557 M. T. of brown rice in 1953 to 2,518,103 M. T. in 1968, with an average annual increase of more than 50,000 metric tons. The total rice output has not only been enough to meet the domestic requirements, but also left a considerable surplus for export (see Table 1), thus contributing significantly to the overall economic development of this country. To strive for further raise in rice production, it is necessary to review and evaluate those factors which had brought about the rice production increase in the past, so that effective measures can be worked out to remove the institutional and technical bottlenecks which have been preventing the unit production of rice from getting still higher.

Expanding of Rice Planting Acreage

According to available data, in 1968 the total cultivated area in Taiwan was 892,907 ha, of which 531,302 ha or 59.50 percent were paddy land, and 361,605 ha or 40.5 percent were dryland. Of the total paddy land, 330,000 ha were double cropping fields and more than 190,000 ha, single cropping areas. It is possible to expand the planting acreage of rice in Taiwan to about 860,000 ha with two rice crops grown in the double-cropping areas and one rice crop in the single-cropping paddy fields in a year. However, the total planted rice acreage in Taiwan has not yet surpassed 800,000 ha. Taking the peak year of 1962 as an example, the actual planted area under rice was 794,228 ha. Therefore, the further increase of rice production in Taiwan, if depending on expanding the planting acreage alone, will require the following measures:

A. *To ensure successful rice culture in water-short areas*

According to a PDAF survey, there are more than 180,000 ha of paddy lands where water supply is irregular or inadequate due to lack of dependable water sources or abnormal dry spells during the year. The magnitude of the water-shortage is shown as follows:

	1st crop	2nd crop	Total
	(ha)	(ha)	(ha)
Without sufficient water or depending on mountain streams	70,985	65,437	136,422
Rainfed area	16,981	27,196	44,177
	87,966	92,633	180,599

In order to remedy the water-shortage situation, the following measures are suggested:

1) To expand and strengthen the rotational irrigation system, and repair and line the irrigation canals so as to make more effective use of the limited water supply as well as to minimize seepage losses.

2) To develop a sound irrigation system on the basis of a ground water survey.

3) To substitute direct-seeding rice culture in a dry condition for the transplanting method, so that the large amount of water used in raising seedlings and making main field preparations can be saved for the normal growth of rice.

4) To encourage farmers to use ground water, by pumping, for supplementary irrigation when a severe dry spell occurs during the rice-growing period.

B. *To prohibit the use of good paddy land for the construction of schools, houses and factories*

Owing to the mounting population growth and the rapid industrialization in recent years, many pieces of paddy land with good irrigation facilities have been used for building schools, houses and factories. The total area, according to the Provincial Food Bureau (PFB), was over 7,000 ha up to 1966. This situation may become more serious in the near future if no proper action is taken. Furthermore, the rice fields adjacent to factories or other buildings will be threatened with flooding during the monsoon season because of the destruction of irrigation and drainage canals. The chemical waste of the factories often do much damage to the rice plants as has happened in the Wu-kou and Tai-shan areas of Taipei county. Therefore, it is advisable to take the following steps in order to stop the practice of using good paddy lands for other purposes.

1) To persuade the official or private quarters to build schools, dwellings or factories on selected dry- or slope-lands rather than good paddy land.

2) If a piece of good paddy land must be used as a factory site, a survey team composed of agriculturalists and irrigation engineers should be organized to investigate the field conditions before the construction takes place, so suggestions can be made to avoid any possible damage to the irrigation and drainage canals as well as to minimize the damage done to crops by waste by-products from the factory.

3) To encourage or even give incentive award to the landowner to grow rice so that the land will not be sold and used for construction purposes.

4) To utilize the winter fallow paddy land for growing dryland crops so as to compensate for the loss of dryland which has been used for the construction of schools, dwellings, and factories.

C. *To stop the practice of growing catch crops or perennial crops on paddy land*

In recent years, more and more of the paddy land in Taiwan has been occupied by catch crops or perennial crops. According to a PDAF survey, a total of more than 7,000 ha of paddy land has been shifted to growing banana, asparagus, citrus and other catch crops. Therefore, it is necessary to induce the farmers to grow these crops on dryland or slope land. The acreage of dryland crops thus lost can be re-created by growing them in paddy fields during the winter fallow period.

Re-appraisal and Revision of Policies and Regulations Concerning Rice Production

A. *Allocation and marketing of fertilizers*

The paddy-fertilizer barter system has been practised in Taiwan for many years. This system makes it possible for the food agency to hold a large stock of rice for the stabilization of its market price. Therefore, this policy is worthy to be continued. For improving the existing paddy-fertilizer barter system, the following suggestions are made:

1) Reducing the kinds of fertilizers to be allocated to farmers: At present, four different kinds of fertilizer are compulsorily allocated to farmers through the paddy-fertilizer barter system. Among the allocated fertilizers, calcium ammonia nitrate, phosphate and potassium fertilizers are usually not acceptable to the farmers. Therefore, it would be better to distribute only ammonium sulphate and urea to the farmers, and allocate other fertilizers only according to their needs or make them available on the free market.

2) Simplifying the distribution procedure: Although the amount of fertilizer allocated to farmers through the township FA is decided by PFB, the actual amount applied is decided by farmers themselves. To simplify the fertilizer distribution procedure, PFB may sell fertilizers to FAs for cash or paddy according to the barter ratio, and farmers will buy fertilizers with cash or paddy from the FAs at any time. Meantime, fertilizers should be made available to businessmen or private concerns by PFB or the Taiwan Fertilizer Company.

3) The requirement for farmers to make advanced payment of 40 percent of the price in paddy for the total amount of fertilizer requested through the barter system should be reexamined.

B. *Readjustment of fertilizer price*

Among all the expenses of rice production, the cost of labor is the largest. The total per hectare labor cost, according to a survey made in connection with the integrated demonstration on improved rice cultivation, is about NT$4,300 or 55.4 percent of the total rice production cost. The second largest item of expenditure is fertilizers, which amounts about to NT$2,500 per hectare per crop (Table 2). If the production cost is in terms of cash investment, the fertilizer cost will constitute about 70 percent of the total expenditure as most of the field operations are done by the family labor of farmers with no cash payment involved. Therefore, the lowering of fertilizer price will not only increase rice farmers' income, but also stimulate them to use more fertilizers, thus further boosting rice production. At present Taiwan farmers pay the highest price in the world for their fertilizers (Table 3). So, immediate action should be taken to lower the fertilizer price to a reasonable level.

C. Modification of the measures for controlling fertilizer marketing

Many kinds of compound fertilizers are sold in the open market and some of them contain the so-called minor elements. These compound fertilizers are, however, low in nutrient content although they are sold at relatively low prices. As the mixed minor elements actually have no direct bearing on the yield of rice, the application of the compound fertilizers is partially responsible for the high production cost. Therefore, the existing measures for controlling fertilizer marketing should be modified.

D. Proper management of manufacture, processing and marketing of pesticides

The cost of pest control in rice culture is about NT$570 per hectare per crop, or 16 percent of the total rice production cost (Table 2). Because of the large consumption of pesticides in Taiwan, the dealers or producers are enjoying a very high profit. This fact has induced many poorly equipped plants to produce pesticides of inferior or doubtful quality. Application of the low quality pesticides will not only increase the production investment, but also reduce the effect of controlling insect pests and diseases. Therefore, it is necessary to revamp the existing system or regulations governing the manufacture, processing and marketing of pesticides.

E. Readjustment of the selling price of rice

Because rice is the staple food in Taiwan, its production, consumption and price level all have an effect on the overall economic development of the island. In recent years, the rate of increase of the price of rice has been way behind that of any other commodities in the country. This is the main reason why farmers have little interest in investing more money in rice production. To encourage rice farmers to pay more attention to rice culture, it is necessary to make a thorough study of the question of rice production cost as the basis for readjusting the rice price properly. When the rice farmers can make reasonable profit from rice culture, they will be willing to invest more money for increasing the rice yield.

F. Stepping up of the consolidation of poorly drained paddy land

The land consolidation program is aimed at raising the work efficiency and improving the irrigation and drainage conditions of the paddy land so as to attain yield increase and reduce the production cost. These effects are more obvious in the case of poorly drained areas. According to a PDAF survey, of the 42,000 ha of poorly drained paddy lands in Taiwan, only 9,000 ha have been consolidated and about 4,000 ha are in the process of being consolidated. In the future top priority in land consolidation should be given this type of land so that the application of improved techniques in rice cultivation in these areas can be made more effective and useful.

Promotion and Extension of Improved Cultural Techniques

In the past decade, the rice production gains in Taiwan were mainly attributable to the increase of per hectare yield. For instance, the per hectare yield of rice in 1953 was only 2,109 kg of brown rice. In 1968 it grew to 3,187 kg, with an annual increase of about 2.5-3.0 percent. In order to meet the future needs for rice, it is necessary to further raise the per hectare yield. This may be achieved through the following measures to bring about the technical and institutional improvements required.

A. *Wider adoption of integrated improved cultural techniques*

The integrated demonstration of improved rice cultivation was initiated by JCRR and began with the second crop of 1963. Up to the 1967 first crop, this program had been conducted at 116 townships each with a demonstration plot of 5 ha. The main items of demonstration were the use of newly-developed superior varieties, raising of healthy seedlings, careful preparation of the field, transplanting at optimum time in the wide-row and close-hill pattern recommended by the various DAISs, proper application of more fertilizers, intensified diseases/pests control and weeding, better management of irrigation and drainage, and harvesting at the proper time. The results of the four-year demonstration program indicated that the average yield from the demonstration plots was about 30 percent more than that of the adjacent check plots, and the net income was about 42 percent higher.

Encouraged by the initial success, the area of land covered in this program was expanded but concentrated in five townships during the 1967 second crop. Two other townships joined the program one year later. In three rice seasons, the second crop of 1967 and the two crops of 1968, there were a total of 14,988 ha participating in the program. The yield increase due to the adoption of the integrated techniques was estimated to be 1,002 kg/ha, a gain of 23.59 percent. Because of its success, the program will be continued during the period of the 5th Four-year Economic Development Plan, to start in 1969, with about 126,700 ha to be covered.

B. *Extension of the wide-row and close-hill planting system*

In the Kao-Ping region, data from experiments and demonstrations indicated that the rice crop planted at a density of 9″ × 4.5″ yielded about 10-15% more than that with a density of 8″ × 7″ or 8″ × 8″. JCRR has supported the local government of this region since 1966 in accelerating the wide adoption of this planting pattern. It is estimated that if all the paddy fields totaling about 100,000 ha in the area are covered by this improved cultural practice, there will be an annual yield increase of about 50,000 M. T.

C. *Replacement of long-stem Taiwan native rice by newly-developed short stature indica rice*

The total acreage of Taiwan native rice has decreased in recent years, but it still occupies about one-fourth of the total area under rice. The long-stem Taiwan native rice is easily lodged with reduced yield, especially under heavy dose of N fertilizer. Efforts have been made in the past to replace the long-stem rice varieties with newly-developed short stature *indica* rice. As a result, the short culm *indica* varieties Taichung (N) 1 and Taichung (S) 2 developed by the Taichung DAIS have been planted on nearly one half of the total *indica* rice acreage in 1968. Unfortunately, these two varieties are low in quality and also easily attacked by bacterial leaf blight. Therefore, the breeding of short-stature *indica* varieties resistant to the prevalent disease and with better eating quality still poses a big problem in rice culture in Taiwan. In the meantime, seed multiplication of the two *indica* varieties should be officially established and PFB should subsidize the seed farms as has been the case with the multiplication of Ponlai rice seed.

D. *Increase of the yield of the second rice crop*

Generally, in Taiwan the average yield of the second rice crop is less than that of the first. As shown in Table 4, this tendency is more pronounced in the Kao-Ping area where the per hectare yield of the second crop used to be about 1,500 kg less than that of the first one, whereas in the Changhua area it was about 1,000 kg and in the Taipei, Ilan, Taichung and Tainan areas, around 500 kg.

The planted acreage of the second rice crop in the above-mentioned areas where most of the rice is produced amounts to some 250,000 ha, accounting for more than 60 percent of the total area of the second rice crop. Apparently, many factors are responsible for the low yield. Besides the natural factors which are beyond human power to control, there are artificial factors that can more or less be manipulated. If improvements can be made in the cultural techniques, such as the wide adoption of disease-resistant, erect and insusceptible-to-lodging varieties, dense planting, split application of fertilizer, effective pest control and better irrigation and drainage, the yield can certainly be raised to narrow the production gap between the first and second rice crops.

E. *Improvement of rice seed multiplication and exchange systems*

A considerable amount of the extension seeds produced by contract-farmers does not pass the PDAF laboratory test every year. The presence of off-type seeds and deficient weight per unit-volume are believed to be the main causes of this failure. A survey made by PDAF in 1966 in central Taiwan showed that only a small number of rice growers had renewed their seeds, while the majority of them were oblivious of this practice. This is possibly one of the reasons why off-type plants and barnyard grass are still found in the commercial paddy fields. The PFB is now engaged in the costly work of roguing off-type plants and barnyard grass in the paddy fields, but this alone will not solve the problem. Listed below are the suggested measures to be taken in rice seed multiplication and exchange to bring about a complete solution to this problem.

1) One variety for one extension-seed grower.

2) Increasing the government subsidy or premium for the extension-seed growers.

3) Increasing the per hectare amount of purchase by the government from extension seed farms.

4) Simplifying the seed exchange procedure, or allowing farmers to buy extension seeds with cash.

5) Establishing more seed exchange stations so as to reduce transportation

difficulties for rice farmers.

6) Shifting the budget for roguing off-type plants and barnyard grass to providing more subsidies to extension-seed growers, and encouraging farmers to exchange seeds.

Strengthening of Research and Training

The development of rice production skills depends on the results of extensive research and experimentation done by qualified research personnel. However, Taiwan does not have enough well-trained technicians and research facilities to meet both present and future needs. To solve this problem, the following steps are suggested:

1) To train more rice technicians at various research stations according to actual needs.

2) To raise the pay scale of technicians so as to increase the efficiency of their work.

3) To offer opportunities for promotion to young technicians and improve the retirement system. In the meantime, selected technicians will be sent abroad for advanced studies so that they will be better equipped for their jobs.

4) To provide more research funds and strengthen research facilities at various research stations. To promote rice production, for example, the PFB may use part of its profit from rice exports and fertilizer allocations for research on rice culture.

5) To invite foreign agricultural experts to visit Taiwan for consultation on research and lecturing in training programs sponsored by local agricultural institutions.

Table 1. Annual Production and Export of Rice in Taiwan (1953-1967)

Year	Planted acreage (ha)	Yield per hectare (brown rice) (kg)	Total production (brown rice) (MT)	Total export (brown rice) (MT)
1953	778,384	2,109	1,641,557	89,525
1954	776,660	2,183	1,695,107	89,850
1955	750,739	2,151	1,614,953	167,133
1956	783,629	2,284	1,789,829	113,850
1957	783,267	2,348	1,839,009	262,931
1958	778,189	2,434	1,894,127	181,762
1959	776,050	2,392	1,856,316	93,725
1960	766,409	2,495	1,912,018	48,116
1961	782,510	2,577	2,016,276	93,374
1962	794,228	2,660	2,112,875	39,373
1963	749,220	2,815	2,109,037	186,407
1964	764,935	2,937	2,246,639	234,765
1965	772,917	3,038	2,348,041	238,661
1966	788,635	3,017	2,379,660	220,817
1967	787,097	3,067	2,413,790	96,040

Table 2. Production Cost of Rice for the Integrated Demonstration Plot

Unit: NT$/ha

Production cost	1964		1965		1966		Average
	1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop	
Labor	3,744.0	3,992.5	4,272.1	4,595.1	4,694.6	4,636.5	4,322.5
Fertilizer	2,798.0	1,995.8	2,502.8	2,353.7	2,511.4	2,451.1	2,435.5
Agr. chemicals	429.0	503.9	670.2	596.0	672.4	593.4	577.5
Seed	274.0	225.8	233.5	246.7	248.3	256.3	247.4
Seed treatment	—	2.5	2.2	12.6	10.7	8.1	6.0
Irrigation	649.0	174.3	209.4	149.7	380.4	58.3	270.2
Others	—	12.9	—	46.1	29.9	47.5	22.7
Total:	7,894.0	6,907.7	7,890.2	7,999.9	8,547.7	8,051.2	7,881.8

Table 3. Fertilizer Prices Paid by Farmers

Unit: NT$/ha

Type of fertilizer	Year	Price in Taiwan*		Price in Japan US$/M.T.
		NT$/M.T.	US$ equiv.	
Ammonium sulphate	1964 1st	3,708	92.1	56.69
	2nd	3,562	89.1	
	1965 1st	3,661	91.5	56.63
	2nd	3,507	87.7	
	1966	3,579	89.5	—
Urea	1964	7,351	183.8	109.86
	1965 1st	7,489	187.2	109.79
	2nd	7,014	175.3	
	1966	7,159	179.0	—
Calcium superphosphate	1964	1,838	45.9	42.08
	1965	1,854	46.3	43.04
	1966	1,873	46.8	—
Potassium chloride	1964	3,267	81.7	57.95
	1965	3,295	82.4	59.29
	1966	3,330	83.3	—

* Converted from rice/fertilizer barter ratios set by PFB.

Table 4. Yield Comparison between the 1st & 2nd Crops in 1965 and 1966

Unit: kg/ha

County/City	1965			1966		
	1st crop	2nd crop	Difference	1st crop	2nd crop	Difference
Keelung City	2,028	1,014	1,014	1,990	1,002	988
Taipei City	2,631	2,571	60	2,527	2,475	52
Ilan County	2,769	2,137	632	2,876	2,282	594
Taipei County	2,560	1,933	627	2,423	1,880	543
Yangmingshan Adm.	3,458	2,280	1,178	3,443	2,262	1,181
Taoyuan County	2,701	2,460	241	2,523	2,348	175
Hsinchu County	2,770	2,566	204	2,524	2,647	− 123
Miaoli County	2,856	2,613	243	2,601	2,700	− 99
Taichung City	3,543	3,511	32	3,273	3,733	− 460
Taichung County	3,809	2,965	844	3,488	3,137	351
Changhua County	4,071	2,743	1,328	3,768	2,830	938
Nantou County	3,477	2,823	654	3,213	2,910	303
Tainan City	3,273	2,368	905	3,206	2,445	761
Yunlin County	3,575	3,415	160	3,325	3,417	− 92
Chiayi County	3,252	3,179	73	3,032	3,224	− 192
Tainan County	3,306	2,890	416	3,456	2,972	484
Kaohsiung City	4,456	2,578	1,858	4,347	2,628	1,719
Kaohsiung County	3,948	2,271	1,677	4,042	2,424	1,618
Pingtung County	4,555	2,750	1,805	4,447	2,982	1,465
Taitung County	2,762	2,749	13	2,805	2,869	− 64
Hualien County	2,815	2,539	276	2,887	2,634	253
Average of whole province	3,418	2,755	663	3,248	2,843	405

SEVERAL QUESTIONS CONCERNING THE RICE VARIETIES GROWN IN TAIWAN

Yung-Chun Lo

Too Many Varieties

In 1966, the total rice acreage in Taiwan was 788,635 hectares, of which 556,393 ha or 70.55 percent was planted to Ponlai varieties, 202,550 ha or 25.68 percent to Chailai varieties, and the remaining 29,692 ha or 3.77 percent to round and oval glutinous rice and upland rice.

Table 1. Planted Area of Rice in Taiwan in 1966

Unit: ha

Crop season	Total	Paddy rice					Upland rice
		Sub-total	Ponlai rice	Chailai rice	Glutinous rice		
					Round	Oval	
1st crop	339,745	338,614	220,365	111,093	5,708	1,448	1,131
2nd crop	448,890	436,648	336,028	91,457	6,005	3,158	12,243
Grand total	788,635	775,262	556,393	202,550	11,713	4,606	13,373

Source: Taiwan Food Statistics Book compiled by PFB

According to information from Taiwan's 12th Rice Improvement Conference, 53 Ponlai rice varieties were cultivated in the first crop of 1966, of which 25 had a planted area of more than 1,000 ha each; while in the second crop there were 52 varieties, 29 of which were planted to an area of more than 1,000 ha each. For Chailai rice, there were 40 varieties in the first crop, with 8 varieties planted to over 1,000 ha each; while in the second crop there were 46 varieties, with 17 varieties planted to over 1,000 ha each.

Table 2. Number of Rice Varieties Planted in Different Areas in 1966

Locality	Ponlai rice		Chailai rice		Locality	Ponlai rice		Chailai rice	
	1st crop	2nd crop	1st crop	2nd crop		1st crop	2nd crop	1st crop	2nd crop
Keelung City	2	2	1	3	Nantou County	7	8	2	6
Taipei City	3	3	2	2	Yunlin County	4	4	3	4
Yangmingshan Adm.	6	6	2	—	Chiayi County	7	5	6	7
Taipei County	7	7	8	7	Tainan County	6	9	7	10
Ilan County	15	13	11	9	Tainan City	4	3	1	3
Taoyuan County	11	12	3	2	Kaohsiung City	4	4	2	4
Hsinchu County	13	19	6	6	Kaohsiung County	14	12	7	11
Miaoli County	11	13	3	3	Pingtung County	15	15	3	7
Taichung City	4	4	3	3	Taitung County	6	4	5	4
Taichung County	17	20	9	7	Hualien County	3	3	2	2
Changhua County	9	9	5	6					

Source: 12th Rice Improvement Conference

The above table shows clearly that many Ponlai rice varieties were grown in such areas as Taoyuan, Hsinchu, Miaoli, Taichung, Kaohsiung, Pingtung and Ilan. As to Chailai rice varieties, too many of them were grown in Ilan, Taichung, Tainan and Kaohsiung. The areas where too many varieties were planted are located near the mountains or along the coast, where the farmers are less skillful at using new cultural techniques. It is advisable to organize the farmers for the extension of a limited number of high-yielding varieties in addition to improving their cultural practices and farm management.

Continued Planting of Old Varieties

According to the length of time required for the extension of the selected rice varieties, those below 10 years are classified as Grade A; from 10 to 22 years, Grade B; and over 23 years, Grade C.

Table 3. Planted Areas of New and Old Rice Varieties in 1966

	1st crop		2nd crop		Total	
	ha	%	ha	%	ha	%
Ponlai rice						
Grade A	16,214	7.36	53,802	16.01	70,016	12.58
Grade B	92,357	41.91	114,402	34.04	206,759	37.16
Grade C	97,844	44.40	150,525	44.79	248,369	44.64
Others	13,950	6.33	17,299	5.16	31,249	5.62
Total:	220,365	100.00	336,028	100.00	556,393	100.00
Chailai rice						
Grade B	71,072	63.98	36,529	39.94	107,601	53.12
Grade C	33,537	30.19	48,588	53.13	82,125	40.55
Others	6,484	5.83	6,340	6.93	12,824	6.33
Total:	111,093	100.00	91,457	100.00	202,943	100.00

Sources: The 12th Rice Improvement Conference and the various agricultural improvement and experiment stations

As shown in the above table, more than 44% of the total planted acreage of Ponlai rice in the two crop seasons was occupied by Grade C varieties in 1966. The same was true of Chailai rice in the second crop, with Grade C varieties taking up an average of 53.13%. Only in the first Chailai crop were Grade C varieties outstripped by Grade B varieties. Conspicuously missing or too little to be worth mentioning was the planting of Grade A varieties in both crop seasons of Chailai rice.

Table 4. Percentages of Planted Areas of Both New and Old Ponlai Rice Varieties in Different Regions of Taiwan in 1966

Unit: %

Locality	1st crop			2nd crop		
	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
Keelung City	—	64.55	7.08	—	52.26	5.81
Taipei City	4.23	27.08	58.26	5.77	28.45	55.07
Yangmingshan Adm.	17.54	3.86	57.05	—	1.34	66.17
Taipei County	12.73	22.81	52.79	12.40	19.22	57.71
Ilan County	12.43	19.35	41.75	—	19.60	51.16
Taoyuan County	—	42.62	41.31	—	36.82	46.82
Hsinchn County	—	21.43	52.57	—	17.12	52.49
Miaoli County	—	20.10	56.31	7.51	5.05	66.91
Taichung City	1.56	54.58	26.67	—	44.02	21.82
Taichung County	—	37.87	35.55	—	39.03	32.96
Changhua County	5.69	54.37	17.89	8.87	54.81	18.27
Nantou County	4.44	60.84	20.59	5.77	53.77	19.65
Yunlin County	12.77	32.10	49.61	34.75	15.07	46.64
Chiayi County	28.55	13.37	56.48	50.38	7.27	41.27
Tainan County	14.95	36.49	47.16	16.71	32.27	46.24
Tainan City	3.98	65.91	30.11	—	48.37	39.10
Kaohsiung City	—	70.84	6.49	—	87.08	—
Kaohsiung County	6.54	79.91	—	7.68	62.07	7.60
Pingtung County	5.16	31.32	40.60	5.59	27.75	44.56
Taitung County	—	10.11	84.37	—	11.26	82.96
Hualien County	—	19.25	70.94	—	15.65	78.33
Whole Province	7.36	41.91	44.40	16.01	34.04	44.79

Sources: Same as Table 3.

Table 5. Percentages of Planted Areas of Both New and Old Chailai Rice Varieties in Different Regions of Taiwan in 1966

Unit: %

Locality	1st crop			2nd crop		
	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
Keelung City	—	—	82.08	—	—	76.98
Taipei City	—	—	100.00	—	—	100.00
Yangmingshan Adm.	—	54.92	22.54	—	—	—
Taipei County	—	—	75.38	—	7.09	69.70
Ilan County	—	5.98	73.00	—	—	94.60
Taoyuan County	—	9.56	81.91	—	10.57	75.64
Hsinchu County	—	12.82	81.89	—	4.33	83.63
Miaoli County	—	45.06	45.06	—	20.29	70.28
Taichung City	—	93.00	—	—	56.32	30.53
Taichung County	—	69.06	26.47	—	64.11	25.44
Changhua County	—	87.19	7.61	—	84.20	12.22
Nantou County	—	88.70	7.61	—	6.83	83.03
Yunlin County	—	92.00	4.22	—	80.11	12.90
Chiayi County	—	53.97	43.06	—	19.48	76.95
Tainan County	—	80.38	15.58	—	27.98	47.00
Tainan City	—	35.00	—	—	19.94	46.06
Kaohsiung City	—	—	89.81	—	—	94.31
Kaohsiung County	—	56.27	17.59	—	9.61	55.20
Pingtung County	—	84.17	10.31	—	13.42	70.74
Taitung County	—	46.09	53.91	—	19.99	80.01
Hualien County	—	30.74	48.07	—	31.43	43.67
Whole Province	—	63.98	30.19	—	39.94	53.13

Sources: Same as Table 3.

The above two tables indicated that in the case of both Ponlai and Chailai rice varieties the proportion occupied by new varieties was very low, and that new varieties were only adopted by some areas, while other areas sticked to older varieties. Presumably there was a lack of varieties adaptable to the local conditions. Thus, strengthening and demonstration of new varieties, improvement of cultural methods, expansion of the scope of integrated cultivation, vigorous extension and selection of varieties adaptable to each rice-growing area are the activities to be carried out in the regions where old varieties are still dominant.

The high proportion of old rice varieties, especially in the second crop season, may account for the gradual decline of the per hectare yield as well as the 10-20% decrease in yield of the second crop when compared with the first crop. Therefore, the strengthening of the selection of improved varieties to replace old ones is of imperative necessity.

The experience of the Republic of Korea in promoting rice production may serve as a fitting example to us. Prior to 1964, there was not enough rice to feed the Korean population, and the situation was eased somewhat in 1965-66, but the price of rice remained high. The government had to earmark 53% of the national budget for stabilizing the price level. However, after the completion of a mammoth urea plant in 1967, and with the improvement of production techniques, rice production in Korea was raised to such an extent that there were surpluses for export.

The low production, according to agricultural experts, was due to the following reasons: 1) lack of superior varieties; 2) 45% of land planted to old varieties; and 3) 44% of the paddy field depending on rainfall for water.

Table 6. Comparison of Per Hectare Rice Yields of Japan, Korea and Taiwan

Unit: kg

Year	Taiwan			Japan			Korea		
	Yield	Index		Yield	Index		Yield	Index	
1946	2,000	100		3,000	100		2,250	100	
1965	3,987[1]	199.35	100	4,895[2]	163.17	100	3,230[3]	143.56	100
1967	4,025	201.25	100.95	4,950	165.00	101.12	3,850[4]	171.11	119.20

Sources: Taiwan Food Statistics Book; Japan Overseas Technical Corps Quarterly; statistics compiled by Ministry of Agriculture, Japan.

1) Improvement of cultural methods, fertilization and reduction of planted acreage of Taichung No. 65 variety.
2) Adoption of new varieties and improvement of fertilization and irrigation.
3) 45% of planted acreage under old varieties.
4) Adoption of new varieties and improvement of fertilization and irrigation.

According to information from the 14th Taiwan Rice Improvement Conference held in 1968, the new varieties Tainan No. 5, Kaohsiung No. 137, Hsinchu Nos. 63 and 54, and Taipei Nos. 309 and 311 have been released for commercial production since 1961. Their total planted area was more than 200,-

000 hectares in 1968, and there is a tendency towards planting more of these new varieties to replace part of the old ones.

Lack of High-yielding Chailai Varieties

The production figures given in the Taiwan Food Statistics Book showed that the highest prewar records of Ponlai and Chailai rice production were attained in 1938, being 2,501 kg/ha and 2,083 kg/ha, respectively. Their yields dropped to an all time low of 1,265 kg and 1,320 kg, respectively, in 1945, the year the war ended. After a period of rehabilitation, rice production began to go up. The prewar record of Chailai rice was smashed in 1954 when 2,193 kg/ha was produced; while a new record of 2,573 kg/ha for Ponlai rice was created in 1958. The yields of 3,258 kg/ha and 3,109 kg/ha for Chailai and Ponlai varieties in 1968 were the highest records to date.

Table 7. Yields of Ponlai and Chailai Rice in Past Years

Unit: kg/ha

Year	Ponlai rice		Chailai rice		Year	Ponlai rice		Chailai rice	
	Yield/ha	Index	Yield/ha	Index		Yield/ha	Index	Yield/ha	Index
1938	2,501	100	2,083	100	1954	2,344	93.7	2,193	105.3
1941	1,929	77.1	1,835	88.1	1956	2,423	96.9	2,247	107.9
1943	1,971	78.8	1,720	82.6	1958	2,573	102.9	2,347	112.7
1945	1,265	50.6	1,320	63.4	1960	2,602	104.0	2,406	115.5
1948	1,648	65.9	1,467	70.4	1964	3,017	120.6	2,886	138.6
1951	2,026	81.0	1,853	89.0	1968	3,258	130.3	3,109	149.3

Table 8. Yields of Ponlai and Chailai Rice in 1st and 2nd Crop Seasons

Unit: kg/ha

Year	1st crop season				2nd crop season			
	Ponlai rice		Chailai rice		Ponlai rice		Chailai rice	
	Yield	Index	Yield	Index	Yield	Index	Yield	Index
1938	2,715	100	2,270	100	2,251	100	1,949	100
1939	2,285	84.2	2,042	90.0	2,173	96.5	1,979	101.5
1942	2,145	79.0	1,934	85.2	1,926	85.6	1,653	84.8
1945	1,440	53.0	1,552	68.4	1,070	47.5	1,164	59.7
1949	1,944	71.6	1,788	78.8	1,583	70.3	1,510	77.5
1953	2,293	84.5	2,082	91.7	2,216	98.4	2,083	106.9
1954	2,512	92.5	2,384	105.0	2,189	97.2	2,046	105.0
1956	2,835	104.4	2,564	113.0	2,098	93.2	1,995	102.4
1958	2,845	104.8	2,598	114.4	2,344	104.1	2,156	110.6
1960	2,829	104.2	2,586	113.9	2,424	107.7	2,267	116.3
1964	3,350	123.4	3,307	145.7	2,799	124.3	2,399	123.1
1968	3,650	134.4	3,502	154.3	3,006	133.5	2,599	133.4

Source: Taiwan Food Statistics Book

As shown in the above two tables, during the few years before and after the end of World War II when both production capital and materials were lacking, the rice yield was very low, particularly that of Ponlai rice. But after 1952, with the extension of two new rice varieties, Taichung Chailai No. 1 and Taichung Sen No. 2, which were bred by local agronomists, the production of Chailai rice was raised almost to the level of Ponlai rice. However, the selection of adaptable varieties for the second crop has to be stepped up in order to further increase the rice production of Taiwan as a whole.

DRYLAND FOOD CROP IMPROVEMENT AND RELATED PROBLEMS

Chih-Kang Chao

Achievements in the Past 15 Years

The JCRR-supported project for dryland food crops improvement was initiated in 1952. Through continuous efforts in the past 15 years, in close cooperation with the local agricultural agencies, remarkable progress has been made in the development of the dryland crops. For instance, in 1967 the production increase was 81% for sweet potatoes, 2.3 times for peanuts, 5 times for soybean, 9.2 times for corn and 9.5 times for sorghum, as compared with the yields in 1952.

Crop	Year	Acreage		Production		Unit yield	
		ha	Index	M.T.	Index	kg/ha	Index
Sweet potatoes	1952	233,502	100	2,090,463	100	8,953	100
	1956	230,236	99	2,568,104	123	11,154	125
	1960	235,387	101	2,978,676	141	12,654	142
	1964	246,002	105	3,347,797	160	13,609	152
	1967	235,808	101	3,776,871	181	16,017	179
Peanuts	1952	80,975	100	60,037	100	741	100
	1956	98,258	121	81,847	136	883	112
	1960	100,497	127	102,167	172	1,017	135
	1964	110,775	137	115,727	193	1,148	155
	1967	97,939	121	136,711	228	1,396	188
Soybean	1952	24,315	100	14,627	100	602	100
	1956	37,505	154	26,442	181	705	117
	1960	59,665	251	52,653	382	882	152
	1964	50,904	209	57,616	394	1,132	188
	1967	52,305	215	75,157	514	1,437	239
Wheat	1952	14,582	100	16,604	100	1,139	100
	1956	15,615	107	27,099	163	1,735	152
	1960	25,208	173	45,574	275	1,808	159
	1964	9,397	64	19,709	119	2,097	184
	1967	11,891	82	23,864	144	2,007	176
Corn	1952	5,115	100	6,981	100	1,365	100
	1956	7,716	151	10,583	152	1,372	101
	1960	13,854	272	20,717	297	1,495	109
	1964	20,015	407	42,100	607	2,207	162
	1967	23,942	468	64,306	921	2,686	197
Sorghum	1952	2,762	100	960	100	348	100
	1956	3,785	137	1,599	167	422	121
	1960	3,248	117	2,941	306	905	260
	1964	2,915	105	2,493	260	855	246
	1967	4,863	176	9,136	952	1,879	534

The main factors contributing to these accomplishments are: 1) the successful development and extension of improved varieties; 2) establishment of the seed multiplication and certification system to supply better and pure seeds for these crops; 3) use of improved cultural practices; 4) increased fertilizer application; 5) effective control of major diseases and insects; and 6) close cooperation and coordination between agricultural research and extension workers. Varietal improvement has played a vital role, especially at the beginning of the program for developing the above-listed crops. The following table shows the unit yields of these crops which have gone up with the acreage expansion of improved varieties:

Crop	Year	Total acreage (ha)	% of acreage, occupied by improved varieties	Yield (kg/ha)		
				Improved var.	Native var.	Provincial average
Sweet potatoes	1952	233,502	25.0	—	—	8,953
	1960	235,387	54.0	—	—	12,654
	1966	235,567	59.5	—	—	14,696
Peanuts	1952	80,795	33.0	—	—	741
	1961	98,615	60.4	—	—	1,061
	1967	97,906	89.0	1,433	1,127	1,399
Soybean	1955	34,510	0	0	700	700
	1963	53,924	53.0	1,074	865	953
	1967	52,291	85.0	1,517	1,004	1,439
Corn	1959	11,566	0	0	1,477	1,477
	1962	16,499	13.0	4,008	1,615	1,976
	1964	21,111	39.0	4,311	1,666	2,103
	1967	24,011	40.0	3,600	2,053	2,669
Sorghum	1955	3,082	0	0	347	347
	1963	3,049	46.0	1,458	227	718
	1967	5,070	59.0	2,725	692	1,881

Problems Concerning Consumption and Production

These crops were formerly used as food supplements, but now they are mainly consumed as feed materials. The estimated percentages of these crops used for different purposes are given in the following table:

Unit: %

Crop	For food	For oil extraction	For feed	For wine making	For seeds and other uses	Total
Sweet potatoes	19	—	75	—	6	100
Peanuts	46	36	(36)	—	18	100
Soybean	29	(69)	69	—	2	100
Wheat	90	—	—	—	10	100
Corn	10	—	89	—	1	100
Sorghum	—	—	74	25	1	100

Sweet potatoes, peanuts and sorghum grown by Taiwan farmers are consumed locally. As the amounts of wheat, soybean and corn produced each year are unable to meet the local requirements, much of them have to be imported. According to the 1966 customs statistics, some 286,000 M.T. or 91% of the total consumption of wheat, 164,500 M.T. (or 72%) of soybean and 64,800 M.T. (or 56%) of corn were imported during that year.

With a view to speeding up the livestock industry, the government relaxed its import control for soybean and wheat in 1966 and for corn in 1967 to increase the supply of feed. An immediate result of this move was a decrease in the planting acreage of these crops in 1968, which has not only led to reduced production but also affected the intensive utilization of land under the multiple-cropping system, because soybean and corn usually are grown three times a year, and in winter they can be planted in paddy fields as soon as the second rice crop is harvested.

Crop	Growing season	Acreage (ha)	
		1967	1968
Soybean	Winter crop in paddy fields	34,214	33,392
	Spring crop	8,004	6,536
Corn	Winter crop in paddy fields	9,282	7,620
	Spring crop	8,702	8,681*
Wheat	Winter crop in paddy fields	11,891	7,714
Rapeseeds	Winter crop in paddy fields	4,498	2,915

* The acreage of hybrid corn for feed use decreased, while that of the native corn for food increased.

Means for Further Development of Dryland Food Crops

As the improvement work for dryland food crops is becoming increasingly difficult under the newly created situation, the following steps should be taken in order to surmount the present difficulties:

1) To increase the unit yields through integrated technical improvement.

2) To cut down the production cost by working out ways to lower the unreasonably high cost of fertilizers and by promoting mechanized farming.

3) To explore the economic value of new crops and find additional uses for existing crops, thus enlarging the scope of development for these crops. To attain this object, some activities have already been initiated, such as (1) establishment of red bean (Adzuki bean) culture in paddy fields; (2) development of vitamin A-rich sweet potato varieties and single-cross hybrid sweet corn into exportable canned items; and (3) development of the young and tender corn ear for table use and canning.

4) To set up efficient storage, marketing and transportation systems for these crops in major producing areas to avoid the sudden drop in price at harvest times.

5) To fix guaranteed prices for soybean and corn producers.

SOME TECHNICAL PROBLEMS IN DRYLAND FOOD CROPS IMPROVEMENT

Chien-Pan Cheng

The production of dryland food crops in Taiwan has been declining under the mounting pressures of lower-priced imported products, increasing production costs, shortage of labor and the lack of an efficient marketing system and a strong and sound government policy. In the face of these problems, intensified efforts are being made to search for ways of dealing with the situation effectively. The highlights of the dryland food improvement program for the future are briefly given below.

Breeding for Early-maturing Varieties

Since most of the dryland food crops, such as corn, soybean and sweet potato, are planted in paddy fields during winter, the duration of their growth is limited to the period between the harvest of the second rice crop and the transplanting of the following rice crop, usually about 110 days. Because of the characteristics of their maturity, most of the existing soybean varieties can fit into this period of time. However, earlier-maturing corn and sweet potato varieties are badly needed for such a cropping system. The breeding for early-maturing corn varieties is being undertaken by the Corn Research Center of the Tainan District Agricultural Improvement Station, and several promising hybrids such as EE-26, and -40, which mature 2-3 weeks earlier than the hybrid Tainan No. 5, are under further testing. The growth periods of the current sweet potato varieties are all around five months, so the relay-interplanting method must be adopted if the farmers want to grow sweet potato in the interval between the two rice crops in their paddy field. Relay-interplanting, of course, is a labor-consuming cultural practice. As the shortage of farm labor will become more serious in the future, further application of this method will be impracticable. Consequently, the development of early-maturing sweet potato varieties has now become one of the main targets of the overall sweet potato improvement program. The quality of earliness in other winter crops, such as rapeseed, broadbean and red bean, is also required.

Breeding for Disease Resistance

As a result of the wider application of various kinds of fungicides and other disease-controlling chemicals in Taiwan, agricultural workers are, more or less, neglecting the fact that the most effective and economical means of controlling plant diseases is through the use of resistant varieties. This is especially true of countries where large areas of land are devoted to producing food crops in great quantities.

The major diseases of several dryland food crops in Taiwan are now becoming more prevalent and tend to be a limiting factor in crop production. They are downy mildew of corn, rust of soybean, corticum wilt and leaf spot of peanut, and a virus disease, Witches' broom of sweet potato. A well-planned and -organized breeding program for disease resistance is urgently needed. The work to be involved will include epidemiological and physiological studies of the diseases, pathogenic studies of the parasites, investigations to ascertain the genetic relationship between host and pathogen, and the use of these findings in a breeding program. The success of such a program calls for close coordination and cooperation between plant breeders and plant pathologists, which have been lacking in the past.

Breeding for Better Qualities

As the living standard on the island is rising steadily, mere yield increases of dryland food crops will hardly satisfy the demand of the people. Further improvement of dryland food crops must lay emphasis on raising the quality or developing crops rich in oil, starch and other desirable elements for providing more nutritional food to the consumers. The following activities are being carried out for achieving these purposes:

1) Breeding for carotene-rich sweet potato—Aside from high starch content, richness in carotene is another quality sought by TARI-Chiayi in its sweet potato breeding program. Carotene is the source of Vitamin-A in human body. Several deep-orange colored and carotene-rich strains like C41-5, C41-74 and C43-83 have been developed. Their carotene content is in the range of 6 to 19 mg per 100 grams of fresh roots; it almost reaches the same levels as found in the leading "yam" varieties of the U.S., and far exceeds the 2 mg per 100 grams of fresh roots for the old carotene-rich variety, Tainan No. 57. Further tests on the yield, other agronomic performances and canning qualities are being made with these promising strains. It is hoped that they can be used in making a new canned food item for export or as a low-priced Vitamin-A supplement for local consumption.

2) Breeding for high-protein corn—Since 1967, the Department of Agronomy, NTU, in cooperation with the Corn Research Center, Tainan DAIS, has been working on a program for breeding high-lysine and high-tryptophan corn varieties. The materials used, two mutants of opaque-2 and floury-2, are the same as for similar programs in the U.S. and Mexico.

As the incorporation of the gene of downy mildew resistance into high-protein variety is a necessity in Taiwan, this program is more complicated than that in any other country.

3) Breeding for soybean and peanut with high oil content—In recent years, one of the objectives of varietal improvement for soybean and peanut has been to raise their oil content. The germ plasm of a number of varieties with high oil content has been collected, and the inherited pattern of such genes is being investigated. These activities are aimed at achieving a break-through of 18-20% oil content for ordinary soybean varieties and a 45-57% oil content for ordinary peanut varieties.

Plant Physiological Studies to be Reinforced

With regard to plant physiogical

studies, not much has been done in Taiwan so far. However, measures for cultural improvement will largely rely upon the findings of such studies. Improved practices that will result in labor-saving, more effective irrigation, herbicide application, fertilization, etc. are urgently needed in the existing program for improving dryland food crop production. In this respect, many related physiological problems must be solved. The lack of qualified plant physiologists to do the planning and research required has impeded the progress of the program.

New Outlets for Dryland Food Crops

The development of new uses for existing crops and exploration of the economic value of other dryland crops may open additional outlets for the Taiwan products on both the domestic and export markets. Canned carotene-rich sweet potatoes have already shown promises as a new export item, though further improvement is needed. Other crops such as baby corn, sweet corn, sunflower, red bean (adzuki bean) and broad bean are all worthy to be developed.

SEED TECHNOLOGY

Cheng-I Lin

Present Status

A. *Kinds of crop seeds involved in seed certification*

—Crops included in the official seed multiplication program—rice, sweet potato, peanut, soybean, wheat, etc.

Official seed certification is obligatory and seed tests are made by the Provincial Seed Testing Laboratory.

—Crops included in commercial seed production:

Hybrid corn, hybrid sorghum, cotton, jute, flax, kenaf—official seed certification by the Provincial Seed Testing Laboratory is obligatory.

Radish, Chinese kale, edible rape and cauliflower—seed certification by the Provincial Seed Testing Laboratory is compulsory.

All vegetables and flowers—certification is done only at the request of seed companies or seed growers.

—All out-going and in-coming crop seeds are subject to commodity inspection as well as quarantine inspection by the Bureau of Commodity Inspection and Quarantine.

B. *Kinds of seed testing presently made*

—Determination of seed moisture content.

—Purity analysis.

—Noxious weed seed determination—flax only.

—Germination test.

—Determination of seed weight.

—Seed health test—rice, radish, Chinese kale, edible rape, cauliflower, sweet potato and potato only.

—Determination of genuineness of species and cultivar—radish, Chinese kale, edible rape and cauliflower.

—Others—solution separation test of rice seeds, shelling percentage of peanut, etc.

C. *Number of samples tested per year and the main reasons for certification failure in Taiwan (1967)*

Number of samples tested:

—Samples from official seed multiplication	3,634
—Samples from commercial seed production,	
field crops	264
vegetables	216
—Samples from out-going seed lots	364
—Samples from in-coming seed lots	355
	4,833

Main reasons for certification failure in Taiwan according to the order of frequency:

—High rate of other varieties or off-type plants in fields.

—High mechanical seed mixture in laboratory analysis.

—Poor sanitary conditions, particularly disease infection in the field.

—Low germination.

—High weed seed content.

—Inadequate isolation of cross-fertilized crops.

D. Seed legislation

No seed law has been enacted in Taiwan. In its place, there are five sets of administrative orders providing the legal basis for the seed control program in Taiwan:

1) Regulations governing the importation and exportation of seeds.
2) Rules and regulations governing seed multiplication and certification.
3) Regulations governing the seed industry in Taiwan.
4) Rules and regulations governing international seed exchange for academic purposes.
5) Rules and regulations governing the nomenclature and registration of new crop varieties.

Also, not officially adopted yet but under pilot trial at present are the rules and regulations governing the activities and qualifications of the licensed field inspectors.

E. International seed exchange

Seed exchange between the Republic of China and other countries has been conducted since the establishment of the International Seed Exchange Center in Taipei in 1960. Approximately 400-1,000 crop varieties are introduced into this country and about 700-800 varieties distributed to some 50 countries annually.

Problems in the Future

A. Legislative problems

Legislative actions necessary for promoting a sound seed industry in Taiwan are listed below in time sequence.

1) Official adoption of the rules and regulations governing the activities and qualifications of the licensed field inspectors.
2) Regulations governing certification and export of seeds produced under contract with foreign buyers.
3) Rules and regulations governing the official listing of crop varieties in Taiwan. (The nomenclature of crop varieties will be included in the regulations.)
4) Administrative order governing the extension of the introduced vegetable and flower varieties in Taiwan.
5) Regulations governing the promotion of private breeding work.
6) Regulations governing the protection of the breeders' rights.
7) The promulgation of a seed law.

B. Production problems

1) For crops included in the official seed multiplication program:
   a. The production of foundation and stock seeds by the Taiwan Seed Service.
   b. Strict observation of the 3-year rotation of seed production.

2) For commercial seed farms:

a. Establishment of a seed growers' association.

b. Strengthening of commercial seed farms through allocation of public land, subsidies or loans for procuring facilities.

c. Cooperative vegetable seed production in split locations.

d. Survey of the production costs of vegetable and flower seeds in comparison with those in other countries.

C. Seed certification problems

1) Separate work stations for the specialized field inspectors of PDAF and readjustment of their duties.

2) Implementation of field inspection and sampling of seeds from the extension seed farms by PDAF field inspectors and/or licensed field inspectors.

3) Establishment of standards for seed health testing and its implementation.

4) Establishment of standards for seed-vigor testing and its implementation.

5) Certification of vegetable seeds.

6) Conducting of seed testing as specified in Article 5 of the Regulations Governing the Private Seed Industry of Taiwan promulgated in 1963.

7) Strengthening of the work of seed testing stations and their facilities and equipment.

D. Seed distribution problems

1) Improvement of packaging and labelling.

2) Establishment of a seed trade association.

3) Strengthening of seed distribution in low yielding areas.

4) Participation, as a member, in the International Seed Federation.

5) Assistance to commercial seed farms in seed marketing.

E. International seed exchange

Strengthening of activities in connection with plant exploration, introduction, preservation and exchange in cooperation with FAO and other countries.

RECENT ACTIVITIES FOR PROMOTING SEED TECHNOLOGY

Chia-Chi Chen

Establishment of the Kun-shan Radish Seed Growers' Committee

To pave the way for the establishment of a seed growers' association in Taiwan, the Kun-shan Radish Seed Growers' Committee has been established at Kun-shan Village, Taichung County. About 100 farmers joined in the mass production of radish seed and produced approximately 18,000 kg of certified seeds from 23 ha of land in 1968. Guaranteed minimum price, provision of production funds, storage of carry-over seeds and cooperative pest control and roguing were the salient points of this project.

Establishment of a Licensed Field Inspector System

To insure that enough field inspectors will be available to perform field inspection and sampling on all the extension seed farms, a licensed field inspector system was established. Selected technicians from both official and semi-official organizations were given intensive training in inspection procedures including field practices in accordance with the Rules and Regulations Governing the Activities of Licensed Field Inspectors. A total of 35 field inspectors for rice and 15 for vegetables have thus been secured, and they will start working in the crop year of 1969/70.

Initiation of Seed Health Testing

To further improve the quality of crop seeds produced for export, the practice of seed health testing has been adopted for rice and four vegetables with modern facilities capable of testing some 500 seed samples a year made available with JCRR financial aid. The standards for routine health testing are now in the process of formulation.

Post-control Testing of Vegetable Seeds for Export

As a measure to determine the homogeneity and varietal purity of vegetable seeds ready for export, seed samples were collected on the wharf and sent to the Taichung and Tainan DAISs with code numbers attached for trial planting. Specialists and seedsmen were invited to attend the field days for indexing the uniformity of each seed sample. However, further improvement in the varietal purity is needed for both radish and edible rape seeds judging from the test results of the first year.

Establishment of the Nation's First Seed Improvement Association

To accelerate the process of modernizing the seed business and promote seed export the establishment of a seed improvement association is necessary in order to pool the knowledge and experiences of those who are engaged in different activities connected with the business. The preparatory work for this association has been completed, and it will be inaugurated upon government approval.

VEGETABLE PRODUCTION IN TAIWAN

Ching-Wu Shen

Introduction

The vegetable acreage has been considerably expanded in recent years because of the increasing demand of the people whose standard of living has been substantially raised. The planted acreage of vegetable crops including mushroom in 1967 was 114,754 hectares, next only to rice and sweet potato. According to the Taiwan Agricultural Yearbook, both the acreage and production of vegetables have been increased more than three times in the past two decades.

Comparison of the Production of Main Agricultural Crops in Taiwan (1967)

Crop	Acreage (ha)	Production (M.T.)	Value per 1,000 kg (NT$)	Total value (NT$1,000)
Rice	787,097	2,413,789	5,499	13,273,106
Sweet potatoes	236,430	3,719,945	821	3,054,780
Vegetables	114,754	1,051,820	1,830	1,924,821
Peanuts	97,906	136,999	7,475	1,024,109
Sugarcane	90,180	6,744,480	222	1,499,905
Fruits	88,128	1,275,101	2,623	3,344,990

Vegetable Production and Per Capita Consumption in Taiwan (1945-1966)

Year	Acreage (ha)	Production		Population		Per capita consumption (kg)
		M.T.	Index	1,000 persons	Index	
1945	35,319	302,575	100	6,090	100	38
1950	74,299	590,981	195	7,554	124	64
1960	91,601	802,801	265	10,792	177	61
1961	90,556	814,182	269	11,149	183	57
1962	94,247	841,409	278	11,511	189	56
1963	101,685	910,695	301	11,883	195	60
1964	101,702	973,875	322	12,256	201	57
1965	108,808	968,159	320	12,628	207	57
1966	112,886	963,281	318	12,993	213	53

Seasonal and Geographical Distribution of Vegetable Production

More than seventy kinds of vegetables are produced in Taiwan at present. According to their geographical distribution the Changhua area or central Taiwan is the center of vegetable production in Taiwan so far as the quantities and kinds of vegetables produced are concerned.

Vegetable Production by Season in 1967

Season	Planted acreage		Production	
	ha	Index	M.T.	Index
Oct. - Dec.	53,378	46.52	545,540	51.87
Jan. - Apr.	23,940	20.86	215,941	20.53
May - Sept.	24,637	21.47	227,097	21.59
Year round	12,799	11.15	63,242	6.01
Total	114,754	100	1,051,820	100

Major Vegetable-Producing Areas in 1967

Production area	Planted acreage		Production		Yield per ha (kg)
	ha	Index	M.T.	Index	
Changhua	15,324	13.35	138,148	13.13	9,015
Taichung	10,770	9.39	105,164	10.00	9,765
Tainan	8,844	7.71	56,852	5.41	6,428
Taipei	8,516	7.42	86,878	8.26	10,202
Yunlin	8,371	7.29	91,036	8.65	10,876
Chiayi	8,249	7.19	78,015	7.42	9,458
Pingtung	8,016	6.99	61,858	5.88	7,717
Kaohsiung	7,938	6.92	68,813	6.54	8,669
Other areas	38,726	33.74	365,056	34.71	9,427
Total	114,754	100	1,051,820	100	9,166

Major Vegetables Produced in 1967

Vegetable	Planted acreage (ha)	Production (M.T.)	Yield per ha (M.T.)	Value per 1,000 kg (NT$)
Radish	10,028	111,264	11.1	891
Cabbage	9,128	110,825	12.1	1,164
Watermelon	8,756	92,318	10.5	1,590
Asparagus	8,002	31,010	3.9	8,313
Chinese cabbage	7,825	74,942	9.6	1,310
Mustard	5,903	60,174	10.2	1,113

Vegetable	Planted acreage (ha)	Production (M.T.)	Yield per ha (M.T.)	Value per 1,000 kg (NT$)
Bamboo shoot	4,465	32,657	7.3	2,572
Cauliflower	3,563	38,867	10.9	1,931
Taro	3,418	20,888	6.1	2,356
Tomato	3,113	35,956	11.6	1,712
Kidney bean	3,059	21,985	7.2	1,937
Oriental pickling melon	2,973	28,519	9.7	1,120
Pea pod	2,935	15,204	5.2	2,370
Scallion	2,889	25,984	9.0	2,190
Garlic	2,483	21,716	8.7	2,649
Water convolvulus	2,397	21,684	9.0	992
Muskmelon	2,242	21,253	9.6	1,730
Cucumber	2,189	21,284	9.7	1,301
Eggplant	1,874	15,391	8.2	1,519
Potato	1,847	23,043	12.5	2,510
Ginger	1,696	13,005	7.7	2,470
Chiu tsai	1,582	16,010	10.1	1,599
Celery	1,545	14,896	9.6	1,540
Mushroom	1,212	50,181	41.4	13,040
Squash	971	8,458	8.7	1,119
Onion	595	22,440	37.7	2,030
Carrot	567	7,580	13.4	2,314
Pepper	509	3,530	6.9	2,342
Waterchestnut	314	3,701	11.8	3,627

Vegetable Exports

The amount of foreign exchange earned by exporting both fresh and processed vegetables increased rapidly from US$1,108,000 in 1958 to US$71,969,000 in 1967.

Value of Vegetable Exports in 1961-67

Year	Canned mushroom (US$1,000)	Canned bamboo shoot (US$1,000)	Canned asparagus (US$1,000)	Fresh and dehydrated vegetables (US$1,000)	Total (US$1,000)
1961	2,048	1,792	—	2,859	6,699
1962	9,792	2,324	—	3,655	15,771
1963	16,993	3,326	—	5,368	25,687
1964	15,899	2,468	411	6,346	25,124
1965	20,803	3,503	11,048	5,745	41,099
1966	25,835	3,089	14,560	6,962	50,446
1967	32,359	4,422	24,720	10,468	71,969

Achievements in Vegetable Improvement (1949-1969)

1) Successful development and extension of new vegetable varieties:

   a. Onion: Texas Early Grano 502, San Joaquin Yellow Globe, Granex and Yellow Dessex

   b. Asparagus: Mary Washington, California 500 and U.C. 309

   c. Szechuan tza-tsai (swollen-stemmed mustard)

   d. Tatou-tsai (large-rooted mustard)

   e. Asparagus lettuce: Celtuce

   f. Brussels sprouts: Jade Cross and Half Dwarf Improved

   g. Broccoli: Italian Green, Texas 107 and Early One

   h. Nodes wax gourd

   i. Okra: Clemson Spineless and Lady's Finger

   j. Vegetable soybean: Fengshan Green Early

   k. Broad bean: Hsinchu No. 2

   l. Strawberry: Marshall, Hungho and Hsinyu

2) Replacement of original varieties with new varieties:

Vegetable	Original variety	New variety
Garlic	Native variety	Fengshan No. 1 and No. 2
Potato	Irish Cobbler	Norin No. 1
Waterchestnut	Native variety	Kueilin Black Skin
Cabbage	Succession, Miike Chusei, O-S Cross	N-S Cross, K-Y Cross, All Season Cross, Sakata Early
Chinese cabbage	Kyoto No. 3	Nagaoka Ideal Market, Tienching
Lettuce	Wayahead	Great Lakes, Imperial
Cauliflower	Native variety	Fengshan Extra Early, Early and Late
Watermelon	Native variety	Sugar Baby, Fukuang, Fupao, Fengshan No. 1 Seedless
Muskmelon	Native variety	Rio Gold, Tainan No. 2, Nungyu No. 1 and No. 2
Tomato	Break O'Day, Pritchard	Manalee, Manalucia, Roma, Red Top
Sweet pepper	Native variety	Ruby King, California Wonder
Kidney bean	Pole Bean variety	Tender Pod, Taipei No. 2
Lima bean	Native variety	Fordhook 242

3) Improvement of cultural practices:

   a. Development and breeding of seedless watermelon

   b. Acceleration of garlic growth

   c. Use of ammonium thiocyanate in breaking the dormancy of seed-potato

   d. Vegetable production in high-altitude areas

Problems to be Solved

1) Research efforts on plant breeding and plant physiology need to be strengthened.

2) A sound seed multiplication and certification system should be estab-

lished to supply pure seeds of better quality.

3) An efficient storage, marketing and transportation system is required for major vegetable-producing areas.

4) Integrated adoption of improved techniques may raise the vegetable yield to a certain extent.

5) Mechanization of vegetable cultivation will help reduce the production cost.

6) There is a need for more funds to support basic research activities.

FRUIT PRODUCTION IN TAIWAN

Kuo-Liang Chang

The demand for more quality fruits for both domestic consumption and export has been growing owing to the increasingly high living standard enjoyed by the people and the sharp competition on the foreign markets. According to the Taiwan Agricultural Yearbook of 1968, the total acreage of fruit orchards in that year was 116,000 hectares, about three times that of ten years ago; and the total production reached 1,327,000 metric tons, four times that of ten years ago.

The purpose of this report is to present a bird's-eye view of Taiwan's fruit production situation and achievements made in recent years and the problems to be solved in near future.

Kinds of Fruit Crops Commercially Cultivated (arranged in a decreasing order according to the amounts produced each year)

1) Banana (*Musa* spp.)
2) Pineapple (*Ananas comosus*)
3) Citrus fruits (*Citrus* spp.)
4) Longan (*Euphoria longana*)
5) Plum (*Prunus salicina*)
6) Guava (*Psidium guajava*)
7) Mango (*Mangifera indica*)
8) Papaya (*Carica papaya*)
9) Pear (*Pyrus* spp.)
10) Litchi (*Litchi chinensis*)
11) Grape (*Vitis* spp.)
12) Peach (*Prunus persica*)
13) Persimmon (*Diospyrus kaki*)
14) Wax apple (*Syzygium samarangense*)
15) Carambola (*Averrhoa carrambola*)
16) Loquat (*Eriobotrya japonica*)

Seasonal and Geographical Distribution of Major Fruits Production

Kind of fruit	Harvesting season	Production area
Banana	Year round	Central and southern Taiwan
Pineapple	Year round	Central and southern Taiwan
Citrus fruits	Year round	Island-wide
Longan	July - August	Central and southern Taiwan
Mango	May - October	Central and southern Taiwan
Guava	Year round	Island-wide
Papaya	Year round	Southern Taiwan
Litchi	June - August	Central Taiwan

The Production and Export Situations of Some Important Fruits in Past Decade

1) Banana:

Year	Harvested area (ha)	Total production (M.T.)	Export	
			Quantity (M.T.)	Value (US$1,000)
1959	12,962	104,474	41,169	6,599
1960	12,709	114,216	48,644	6,851
1961	14,751	129,669	76,506	10,700
1962	14,874	140,875	57,544	8,000
1963	18,086	132,489	60,650	8,700
1964	14,718	267,898	200,977	33,300
1965	27,433	460,094	337,475	55,300
1966	36,512	527,721	370,212	52,600
1967	44,107	653,800	426,771	62,000
1968	43,794	645,330	385,486	56,803

2) Pineapple:

Year	Harvested area	Total production	Export				Total value
			Canned		Fresh		
	(ha)	(M.T.)	Quantity (1,000 std. c/s)	Value (US$1,000)	Quantity (M.T.)	Value (US$1,000)	(US$1,000)
1959	8,884	145,923	1,742	8,340	—	—	8,340
1960	9,745	166,730	1,764	8,486	—	—	8,486
1961	9,737	173,547	2,247	12,080	—	—	12,080
1962	10,525	192,307	2,323	10,859	—	—	10,859
1963	9,570	163,307	2,316	11,570	—	—	11,570
1964	10,478	226,682	2,776	13,930	—	—	13,930
1965	11,090	231,005	3,798	19,376	7,090	1,080	20,456
1966	12,017	270,389	3,878	19,305	19,355	2,950	22,255
1967	11,851	296,081	3,987	19,308	20,782	3,167	22,475
1968	11,842	311,362	3,790	18,500	21,648	3,200	21,700

3) Citrus fruits:

Year	Harvested area	Total production	Export				Total value
			Canned		Fresh		
	(ha)	(M.T.)	Quantity (std. c/s)	Value (US$1,000)	Quantity (M.T.)	Value (US$1,000)	(US$1,000)
1959	7,381	42,567	—	—	—	—	—
1960	8,099	52,866	—	—	2,115	391	391
1961	9,033	54,927	5,268	—	4,469	929	929
1962	10,246	67,141	7,732	46	4,603	1,288	1,334
1963	11,292	78,680	75,138	448	5,212	1,387	1,835
1964	13,361	102,341	392,859	2,347	6,185	1,471	3,818
1965	14,694	114,434	499,922	2,987	7,164	1,691	4,678
1966	15,965	136,695	247,228	1,477	6,850	1,557	3,034
1967	17,706	155,324	316,732	1,892	6,995	1,431	3,323
1968	18,438	170,828	412,000	2,500	9,870	2,107	4,607

Improvement Programs Sponsored by JCRR in Recent Years

1) Varietal improvement through introduction and selection—The introduction of new kinds and new varieties of fruits from abroad has been done periodically in the past. Some exotic varieties of fruits such as sweet oranges, mango and passion fruits were introduced from the United States, apple, pear and cherry from the USA, Japan and Europe, banana from Central and South Americas, and macadamia nut from Hawaii. Some of them are grown commercially now and others are still under observation. The kinds of fruits which have been improved through varietal selections are pineapple, litchi and longan.

2) Increase of the unit yields of pineapple and banana through the adjustment of their planting spaces and improvement of fertilizer applications.

3) Continuation of citrus improvement research for finding superior rootstock varieties resistant to tristisa diseases.

4) Consolidation and cooperative management of major homogenous orchards for upgrading the fruit quality and lowering production cost.

5) Demonstration of orcharding techniques for deciduous fruits in mountain areas.

6) Assistance to the Fruit Marketing Cooperatives to set up assembling and packing houses in various fruit-producing areas for improving packing techniques and upgrading fruit quality for export.

Problems to be Solved

1) High production cost due to high prices of production materials and high labor cost.

2) Inefficient field management of the numerous small-sized and widely scattered groves.

3) Lack of time-saving machinery for use in slopeland orchards.

4) Need for a well organized agency responsible for the export of processed or fresh fruits.

5) Unstable fruit exports resulting in unsteady income of growers.

6) Heavy taxes hindering the development of juices and other fruit products for both domestic and foreign markets.

7) Lack of sufficient funds for conducting basic research activities.

ASPARAGUS PRODUCTION IN TAIWAN

Lih Hung

Introduction

Through the vigorous efforts of farmers and canned food manufacturers, and the technical guidance of JCRR, asparagus has within six years become a major export crop of Taiwan. In fact, the Republic of China is now the top asparagus exporting country in the world. It is often a surprise to foreign horticultural experts that asparagus, a vegetable of the temperate zone, could have been developed into a successful agricultural industry in a tropical area such as Taiwan.

History

Asparagus culture in China can be traced as far back as the Ming Dynasty (15th century), though no large-scale cultivation was recorded. In 1935, the Taipei DAIS introduced and undertook to test the Palmetto variety, but failed to attract the attention of the vegetable farmers. In 1953, the same station made a second attempt to introduce such asparagus varieties as Mary Washington, UC 309, UC 711, etc. for its varietal trials. Soon a few farmers began growing asparagus on a small scale. An initial effort to fit asparagus into the schedule of the local canning factories, which were mostly engaged in mushroom canning, produced very satisfactory results. Since then, canned asparagus has been booming as one of the important exports of Taiwan.

Production

The scope of asparagus production in Taiwan is given in the following tables.

Table 1. Production and Export of Asparagus

Year	Planted area (ha)	Production (M.T.)	Unit yield (kg/ha)	Export (case)	Export value (US$)
1963	105	441	—	335	4,355
1964	270	616	2,280	33,244	410,952
1965	9,533	16,776	1,760	801,244	11,047,654
1966	10,877	44,120	4,056	916,328	14,218,221
1967	7,767	31,010	3,992	1,744,509	23,956,381

Source: Taiwan Agricultural Yearbook and Taiwan Exports of Canned Food

Table 2. Asparagus Acreage in 1968

County	Hectares
Changhua	2,267
Chiayi	1,195
Yunlin	1,012
Pingtung	752
Tainan	613
Taichung	464
Other areas	635
Total	6,938

Source: 1969 Report of the Taiwan Provincial Farmers' Association

Table 3. Quantity & Foreign Exchange Value of Canned Food Exports in 1967

	Quantity	Value
Total export	9,478,522 cs.	US$83,110,891
Pineapple	42.06 %	23.23 %
Mushroom	24.30	38.78
Asparagus	18.41	28.82
Bamboo shoots	6.25	2.75
Water chestnut	3.35	1.77
Mandarin orange	3.34	2.28
Others	2.29	2.37

Source: Taiwan Exports of Canned Food 1967

Table 4. Canned Asparagus Exports of Major Countries (1962-1967)

Unit: 1,000 cases

	1962	1963	1964	1965	1966	1967
Belgium-Luxemburg	32.7	22.5	25.5	33.2	26.5	19.5
France	84.0	65.3	56.0	56.0	36.7	29.0
Japan	156.5	153.7	135.1	160.5	56.1	173.5
Netherlands	98.3	102.2	102.9	90.4	72.9	49.2
Spain[1]	—	190.1	325.5	555.8	261.3	Unavailable
Taiwan	—	—	55.4	1,375.6	1,703.4	Unavailable
United States[2]	2,673.4	2,717.9	2,715.1	1,366.3	1,318.0	668.6

1) For year beginning October 1 previous to year shown.
2) For year beginning April 1 of year shown.
Source: USDA Foreign Trade in Fresh and Processed Vegetables

Table 5. Canned Asparagus Imports into West Germany

Year	Percent of total imports	
	From U.S.A.	From Taiwan
1961	83.8	—
1962	85.2	—
1963	83.2	—
1964	76.1	1.4
1965	49.0	26.2
1966	27.5	59.3
1967	11.8	80.4

Source: USDA Foreign Trade in Fresh and Processed Vegetables

Table 6. Asparagus Production Costs in Taiwan

Unit: NT$/ha/year

Items	First year			Second year			Third year		
	NT$		%	NT$		%	NT$		%
Rent of land		6,000	16.8		6,000	16.4		6,000	15.7
Soil preparation and planting		1,800	5.0			—			—
Seedlings		3,500	9.8			—			—
Compost	9,000			8,400			9,600		
Fertilizer N	4,200			4,340			4,480		
Fertilizer P_2O_5	680	15,700	43.9	624	16,400	44.8	620	17,800	46.6
Fertilizer K_2O	320			1,536			1,600		
Labor for application	1,500			1,500			1,500		
Cultivation (weeding & ridging)		1,900	5.3		2,000	5.5		2,200	5.8
Irrigation		1,500	4.2		1,500	4.1		1,500	3.9
Harvest		4,500	12.6		9,000	24.6		9,000	23.6
Pests control		900	2.5		1,700	4.6		1,700	4.5
Total		35,800			36,600			38,200	

Source: Quarterly Bulletin of the Bank of Taiwan, 17(1):143

Research

Research does not seem to have kept pace with the rapidly developing asparagus of Taiwan. For lack of well-trained research personnel, facilities and adequate budget, progress in this respect has been rather slow. If the booming asparagus industry is to be maintained in the future, timely support to well-planned research projects is necessary.

How to Promote Asparagus Production in Taiwan

1) To strengthen varietal trials in order to find the best asparagus variety adaptable to the climatic conditions of

Taiwan.

2) To start asparagus breeding and seed production immediately.

3) To adopt different cultivation systems for different areas.

4) To lower the cost of production by making cheaper or reasonably priced fertilizers available.

5) To establish a sound post-harvest handling system for both the growers and the canning industries.

THE JCRR TEA IMPROVEMENT PROGRAM AND THE FUTURE DEVELOPMENT OF TAIWAN'S TEA INDUSTRY

Pa-Lun Chang

General Situation

About 36,000 ha of land is now planted to tea in Taiwan. The unit yield of green tea leaves is fairly low. According to a report published in the World Coffee and Tea in 1967, the average per hectare yield of Taiwan's made tea was only 560 kg which amounted to about 30% and 50% of the unit production in Japan and India, respectively (Table 1). Although the unit yield of made tea was increased to more than 700 kg in 1968, it was still low, compared with the major tea-producing countries of the world.

Over 88 percent of the tea in Taiwan is produced for export. During the past decade, the foreign exchange earned from tea exports rose steadily from US$7 million in 1959 to US$11 million in 1968. This export increase, however, still can not match that of canned foods (mushrooms, asparagus and pineapple) and bananas, which have become the primary earners of foreign exchange among the agricultural products in recent years. Furthermore, due to the low quality of the different kinds of tea produced, the market prices for them over the past few years have been very low and it is difficult to dispose of the low-grade tea, particularly the black tea.

Table 1. Acreage, unit yield and production of tea in chief producing countries (1966)

Country	Acreage (ha)	Production (M.T.)	Unit yield (kg/ha)
India	345,000	374,000	1,080
Ceylon	241,000	222,000	920
Pakistan	37,000	28,000	750
Indonesia	66,000	30,000	450
USSR	70,000	56,000	800
Japan	48,000	83,000	1,720
Taiwan	37,000	24,000	560

Source: World Coffee & Tea, July 1967

Major Activities and Achievements

Since 1950 efforts have been made to increase local tea production under JCRR-initiated programs. The notable technical innovations of the tea industry during the past two decades include the following: (1) multiplying and distributing to farmers the first batch of 19.5 million tea seedlings of improved varieties as replacements for the missing plants on 10,000 ha of tea farms during 1951-1953; (2) assisting the Taiwan Tea Corporation to rehabilitate a total of 756 ha of the degenerated Assam tea farms in the Yuchih area of Nantou County from 1950 to 1952; (3) demonstrating the use of calcium cyanamide and extending a large quantity of Lupine seeds to tea growers as a green manure crop for replenishing soil nutrients and organic matter in 1950 and 1951; (4) conducting a large-scale demonstration on improved cultural practices for 99 ha of tea farms scattered over seven counties, resulting in significant increases in unit yield of up to 80% within three years from 1960 to 1963; (5) assisting PDAF in conducting an educational and supervisory project on 10,000 ha of tea farms in seven counties for the introduction of new cultural methods among tea growers, resulting in raising the average unit yield of made tea from 350 kg in 1958 to more than 700 kg in 1968; (6) assisting the Taipei County Government to renew some 3,400 ha of old and degenerated tea varieties during 1961-69; (7) rendering assistance to the Yuchih branch station of the Taiwan Tea Experiment Station (TTES) in establishing a nursery capable of propagating 1,500,000 seedlings a year by the cutting method, which has replaced the traditional seeding method for the propagation of Assam tea in Taiwan; (8) assisting the Taitung County Government in establishing 100 ha more of Assam tea farms in line with the policy of expanding Assam tea planting in eastern Taiwan during the past four years; (9) assisting the tea experiment stations in developing a number of new tea varieties, such as Tainung Nos. 29, 77, 143, 8, 121, 101, 69, 705 and 478 of the small-leaf varieties and Nos. 184, 5118 and 239 of the Assam tea varieties which, being much superior to the existing varieties, have been gradually propagated and extended to tea growers for general planting; and (10) constructing a refrigerated room at the TTES for conducting cold storage trials on tea in order to preserve its flavor for a longer period. In addition, JCRR gave assistance to the tea experiment stations as well as tea factories to strengthen their equipment and laboratory facilities including CTC and CCC tea-making machines, automatic dryers, green tea machines, trough withering system, sifting and grading equipment, etc. All these machines or equipment have helped greatly the improvement of the local tea industry.

As a result of government's implementation of the four Four-year Plans from 1953 to 1968, both the tea production and the export volume have been raised. As shown in Table 2, much progress has been made in the development of Taiwan's tea industry in the past sixteen years.

Table 2. Production and export of Taiwan tea during the period of the four Four-year Plans (1953-1968)

Item		1952 (Before 1st 4-year Plan)	1956 (Last year of 1st 4-year Plan)	1960 (Last year of 2nd 4-year Plan)	1964 (Last year of 3rd 4-year Plan)	1968 (Last year of 4th 4-year Plan)
Acreage	ha	44,120	47,638	48,432	38,176	36,113
	Index	100	107	109	86	81
Per hectare yield of crude tea	kg	305	310	380	520	712
	Index	100	101	124	170	233
Production of crude tea	M.T.	11,582	13,420	17,365	18,306	24,418
	Index	100	115	149	158	210
Export of refined tea	kg	9,479,329	10,633,640	11,437,273	14,937,076	18,384,364
	Index	100	112	120	157	193
Export value	US$	5,745,270	5,050,905	6,347,000	8,426,000	11,681,000
	Index	100	87	110	146	203

Problems Encountered

Although the per hectare yield of tea in Taiwan has been increased in recent years, it is still far behind those of other tea-producing countries of the world. The difficulties encountered by the industry are briefly stated as follows:

1) Lack of coordination among farm production, processing and marketing—Taiwan's tea industry consists of the tea growers, the crude tea factories, the refined tea factories and the exporters. This not only causes work inefficiency and high production cost to the industry, but also seriously obstructs the progress of tea business management. Thus, Taiwan's tea export has not been as successful as it should.

2) Low unit yield and inferior quality of green tea leaves—The low yield of tea is due to: (a) poor management, (b) insufficient fertilizer application, (c) low grade of soil generally used for planting tea, (d) a high percentage of missing plants, (e) serious soil erosion in tea farms on hilly land, (f) about 30% of the tea farms being too old and degenerated, etc. The low yield of green leaves naturally results in higher production cost which has made Taiwan-produced tea less competitive on the world market.

The quality of green leaves is most important to tea manufacture. In Taiwan, however, excessive plucking of leaves is common as seen in the large number of coarse tea leaves, which results in the poor quality of made tea. The main cause of excessive plucking is the lack of a grading system for the tea factories to purchase green leaves. The farmers, in order to get more leaves, do not follow the practice of standard plucking.

3) Existence of substandard tea factories—Most of the tea factories do not have standard facilities and equipment for making good tea. They pay more attention to cost reduction than quality improvement. Thus, the proportion of inferior tea has been increasing in recent years.

4) Lack of long-term and low-interest production loans for tea growers—Approximately 11,000 ha or 30% of the total tea acreage is degenerated and in need of replanting with high-yielding varieties. To do this, sufficient funds for making long-term and low-interest production loans will be needed. At present, however, the interest on loans from local banks is too high for the growers to use them for replanting activities.

5) Lack of working capital on the part of tea factories—A large number of tea factories are short of funds for purchasing green leaves or crude tea and for processing operations. To meet their needs, they have to borrow from the black market or banks by paying a high interest which will eventually increase the production cost of made tea. This is one of the reasons why the crude tea factories have often depressed the price of green tea leaves.

6) Lack of a sound marketing system—There are too many people engaged in the export of tea, many of whom have little or no capital at all. Such people certainly do more damage than good to the industry. Transactions of crude tea and refined tea between tea factories and exporters are done through brokers, for lack of a sound tea marketing system, there is also no efficient organization of the tea exporters who often compete with one another by offering lower prices to buyers. The unhealthy competition in tea export has greatly affected the whole industry. For instance, the prices of green leaves and crude tea have been so depressed that many of the tea growers and the crude tea factory owners have lost interest in improving their business. Therefore, both the unit yield of green leaves and the quality of made tea remain low despite repeated government efforts.

Direction of Future Efforts

Although there are many problems in our tea industry, the importance of tea should not be overlooked as it concerns the livelihood of a large number of farmers and the proper utilization of large tracts of land. In order to remain competitive with other countries, the following measures for the improvement of Taiwan's tea industry are suggested:

1) To organize a "Tea Supervisory Committee" under the Board of Foreign Trade, MOEA, to be composed of representatives from related agencies and tea experts, for taking a coordinated approach to problems in farm production, processing and marketing, and for formulating a policy whereby the production and marketing of tea can be improved.

2) To raise the unit yield of quality tea leaves through the following methods: (a) carrying out a renewal plan for the old tea farms in western Taiwan with the planting of the newly developed early-maturing varieties so that the unit yield of quality tea leaves can be increased to help expand or develop the market for our green tea and partially fermented tea in Japan and other countries; (b) establishing more Assam tea farms in eastern Taiwan to increase the production of black tea for export; and (c) strengthening the educational and supervisory programs for the introduction of new cultural methods such as the use of compound fertilizers, pest control with labor-saving machines, the appli-

cation of automatic plucking devices, etc. so as to increase substantially the unit yield of made tea.

3) To encourage and help tea factory owners to modernize their equipment, and to improve their manufacturing techniques for increasing the production of quality tea.

4) To provide enough low-interest loans for both tea growers and tea factories to meet their needs in replanting their lands and improving their processing techniques.

5) To set up a local tea market for normalizing the marketing practices, and to organize the tea exporters into groups for the joint export of green tea and black tea.

6) To strengthen basic researches and experiments at the tea experiment stations for the development of new varieties, improved cultural practices and better processing techniques for further boosting the production of quality tea.

SOIL FERTILITY RESEARCH IN TAIWAN

Yen-Sun Puh

Before 1960, soil fertility studies in Taiwan were conducted mainly to find out the general fertility characteristics of crops and their responses to fertilization. By soil analyses and fertility trials, the rate and kind of fertilizer to be applied were determined. The results of the studies were used as a basis for fertilizer allocations.

Owing to the fact that further increase in fertilizer rate alone can no longer lead to substantial yield increases for some crops, like rice, sugarcane and tobacco, both the nature and scope of the soil fertility study have changed in recent years. The following are some of the important activities or findings:

1) Physiological disorders of rice are affected by soil conditions and their amelioration. Soil ridging, sufficient application of potash, soil drying and drainage, and use of MnO_2 have been found effective in controlling the so-called suffocating disease.

2) Rice production can be increased through a top-dressing of nitrogen fertilizer. Data from a 3-year study involving a total of 72 field experiments covering all major areas indicate that the more the top-dressing of nitrogen is applied, the higher the yield will be. The farmers usually completed their fertilization within 30 days after transplanting. However, over 90% of the experiments showed that nitrogen application at later growth stages was more effective in increasing the yield. The average increase was 7.8%. The practice is better for the second crop than the first crop. Maximum efficiency of the nitrogen top-dressing can be attained if it is applied about 25 days before heading. The increase in yield ranged from 2% to 34%, with an average of 10%. The results obtained are encouraging and practical as well. In cooperation with TFB and TFC, JCRR has set up 165 demonstration plots to teach farmers to adopt this practice since 1967.

3) There is a wide distribution of acid soils in Taiwan, particularly in the northern part of the island. During the past two years, an acid soil survey project has been implemented. A total of 160,000 hectares of croplands in three counties had been mapped by June, 1968. The project is expected to be completed at the end of the same year.

Many agricultural policy makers recently stressed the importance of developing mountain areas for crop production. However, most of the slopelands for agriculture use in Taiwan are strongly acid. Except a few crops which are acid-adaptable, the soil acidity would be detrimental to most crops. Research on liming to reduce the soil acidity is important. Although considerable work has been done in this respect, further effort is needed.

4) The yield of the second rice crop is always lower than that of the first. The causes of this are still not clear to us. Plant nutritionists strongly believe that the lower yield of the second crop is associated with the uptake of nutrients by rice plants under the high temperature condition. For raising the production of the second crop, an intensive study has been carried on since 1966, and the preliminary results will be published shortly.

5) Soil tests and plant analyses have been developed as guides to fertilization. Most of the soil tests has been conducted on flooded (paddy) soils, using rice plants as the indicator crop. During the past two years, efforts have been directed to major upland crops such as citrus, corn, sweet potatoes, tea, bananas, and pineapple. Since soil test and plant test are complemental to each other and crop characteristics are widely different, both tests should be equally emphasized and developed as diagnostic tools to make possible better fertilization of individual crops.

6) In the nutro-physiological field of rice, emphasis has been placed on nutrient uptake as affected by temperature, silica nutrition, and nitrogen- and potash-variety relationships.

7) The basic objectives of the soil test are to provide farmers guidance on better and more economic use of fertilizers and to improve soil management practices for increasing crop production. In Taiwan, with chemical fertilizers under government control, the soil test has an additional advantage, i. e., it can serve as a reference to the government in planning fertilizer allocations.

In view of the importance of soil fertility research, JCRR has helped TARI set up a Soil Fertility Laboratory and a soil testing system in Taiwan. Every effort has been made to select suitable chemical methods and correlate crop reposes with soil test values. By June 1968, the fertility status survey of cropland on an island-wide basis was completed. Under this program, more than 80,000 samples, covering about 800,000 hectares of agricultural land, have been collected and analysed. The results obtained from the soil tests have been compiled, and maps on the 1:100,000 scale are to be distributed for use in various areas. For each county, a set of maps have been prepared, showing the soil texture, reaction, organic matter, available phosphorus and potassium in the region.

FERTILIZER PRODUCTION AND MARKETING IN TAIWAN

Chun-Muh Wong

Production

The fertilizer industry of Taiwan prior to World War II was a small one. Its peak production was 33,858 M.T. in 1939, representing only about 5% of the total consumption, while the remaining 95% came from imports.

Immediately after the restoration of Taiwan to China, the Government took over the war-torn industry and established the Taiwan Fertilizer Company (TFC) to start rehabilitation and construction of new fertilizer plants. In 1948, the fertilizer output was 38,329 M.T., which already surpassed the production record of the past. In 1950, the Taiwan Provincial Government purchased an ammonium sulfate plant from the arsenal and reorganized it into the Kaohsiung Ammonium Sulfate Corporation (KASC) which is the first synthetic ammonia plant in Taiwan. The capacity is, however, small, producing only some 6,000 M.T. of ammonium sulfate a year.

The 4-Year Economic Development Plan was launched in 1953. Prior to that time, most of the fertilizers were obtained through the U.S. aid. The development plan provided for the expansion of the local fertilizer industry to minimize the use of foreign exchange for fertilizer imports. New plants including nitrochalk, nitrophosphate and urea were completed during the second 4-Year Plan. When natural gas was discovered in Taiwan, the Mobil Oil Company and the Allied Chemical Company entered into a contract with the Chinese Petroleum Corporation to set up the Mobil China Allied Chemical Industries Ltd. (MCACI) in the form of a urea plant with an annual capacity of 100,000 M.T. and to supply additionally 45,000 M.T. of ammonia to the Taiwan Fertilizer Company for manufacturing ammonium sulfate. According to an estimate made in 1962, the fertilizer production capacity in Taiwan would amount to 160,000 - 170,000 M.T. of nitrogen in 1966. However, the manufacturing processes of nitrogen fertilizers by TFC and KASC were rather old in comparison with MCACI's, and therefore their production cost was too high to compete with imported products. In order to bring down the cost, the authorities decided to build a new fertilizer plant on an economically sound scale, which would utilize natural gas to produce nitrogenous fertilizers to replace the more expensive calcium cyanamide, with the surplus, if any, to be exported. At the same time, a phosphoric acid plant was constructed by TFC for manufacturing various grades of concentrated compound fertilizers. The construction of these two plants was completed in 1968.

At present, TFC, KASC and MCACI produce 98% of the total N fertilizer requirement of Taiwan, with the remaining 2% by two small private companies using the ammonia supplied by TFC. All the ammonium sulfate produced is delivered to PFB for overall distribution. Phosphate fertilizers are produced entirely by TFC. The small companies have no ammonia plants of their own. They purchase urea from TFC, or ammonia from KASC and other straight fertilizers from the market for preparation of mixed fertilizers, and their total production is negligible as compared with that of TFC, KASC and MCACI. From the Table 1, it can be seen that N production has increased tremendously in recent years, resulting in decreased imports of the same. P production reached self-sufficiency in 1965 and there has been no import since then. Taiwan does not produce potash and its import has been on the increase.

As regards the kinds of fertilizers, Taiwan once produced fused phosphate and the plant was closed down in 1960 due to the high cost of production. Before the manufacturing of compound fertilizers, superphosphate was the only phosphatic fertilizer produced locally. At present, superphosphate makes up about 90% and compound fertilizers 10% of the total phosphate production. Among nitrogenous fertilizers, calcium cyanamide and nitrochalk are being replaced by urea and ammonium sulfate. The cost of urea production is less than that of ammonium sulfate on the unit nitrogen basis. However, because of the farmers' preference and market demands, Taiwan still must produce a large amount of ammonium sulfate for meeting the domestic requirement. Of the total nitrogenous fertilizer production, urea constitutes about 50%, ammonium sulfate 35%, nitrochalk 5% and compound fertilizer 10%. The chart shows the percentage changes of different types of N-fertilizers in total production.

Distribution and Use

Chemical fertilizers are listed as "controlled items" among imported commodities. Most of the locally produced fertilizers are turned over to PFB and TSC for distribution. Briefly speaking, the supply and distribution of fertilizers for TSC's own farms and its contracted growers are handled by TSC. The contract growers get fertilizer on a loan basis, and repay it to TSC after harvest by deducting the amount from their share of the sugar sales proceeds. Fertilizers for crops other than TSC sugarcane are handled by PFB. Agricultural institutions and outlying islands (Kinmen) get their fertilizers by applying direct to the PFB, and the farmers through the farmers' associations.

The farmers' associations distribute fertilizers in accordance with the PFB's regulations as follows:

1) Farmers are required to barter rice for fertilizers allocated for rice crops. Those who are short of paddy may apply for a loan to be repaid in kind following the rice harvest. However, the amount of fertilizers distributed on a loan basis should not exceed 60% of the total as a whole.

2) Fertilizers for crops other than rice are sold on a cash basis. The Taiwan Tobacco & Wine Monopoly Bureau, the Taiwan Supply Bureau, the Taiwan Brown Sugar Guild, etc., which are willing to finance their respective contract growers in getting fertilizer allocations for tobacco, jute,

sugarcane, etc., make arrangements with PFB for advanced payment, and the fertilizers are distributed through farmers' associations.

Table 2 shows the amounts of fertilizers distributed through the barter system and cash sales in the past 19 years. The gross quantity distributed in 1968 was nearly one million M.T. which was 3.4 times that of 1950. Rice barter accounts for 70-80% of the total, and the balance is distributed on a cash basis.

Fertilizers distributed through the barter system are supposed to be used on rice only. Owing to the rice collection policy of the Government, the amount of fertilizer allocation has been increased and farmers are encouraged to take more fertilizers under the system. Therefore, the distribution figures by no means represent the actual consumption by any particular crop. However, the total distribution for all crops in the long run can be used as reference in estimating the consumption. Tables 3 and 4 show the NPK consumption for all crops in Taiwan and the average consumption per unit area of arable land in comparison with other countries. As shown in these tables, NPK consumption has increased 140%, 60% and 294%, respectively, in the last 15 years. The percentage increase of K is the greatest, and quantitatively, N is the largest. Based on the area of the arable land, the annual per hectare consumption of N, P_2O_5 and K_2O in Taiwan averages 195 kg, 44 kg and 66 kg, respectively. The N consumption rate ranks among the highest in the world and the seventh for total NPK rates in 1965/66. Even taking into account the multiple-cropping practice, the rate of fertilizer application in Taiwan is still high.

Problems and Suggestions

1) High cost of fertilizers: In Table 5, it is shown clearly that the prices of NK fertilizers paid by Taiwan farmers are the highest in the world. Such high prices are due not only to the high cost of production, but to the high profit margin designed by the government agencies concerned.

2) Institutional shortcomings: Since the Provincial Food Bureau is responsible for food administration and control, rice collection is its most important job, and fertilizer distribution is used as a tool for rice collection. Many farmers cannot get fertilizers from the farmers' association on a cash basis, and for them they have to pay more under the barter system.

The fertilizer allocation system is still being practised even when supply has already surpassed demand. It is suggested that farmers be allowed free choice in purchasing fertilizers as to types and quantities.

3) Coordination of production and marketing: The increase of fertilizer consumption has levelled off in recent years, and may further slow down in the future. Therefore, the surplus N-fertilizers have to be exported. Since the fertilizer prices in the international market are declining, the industry itself is of the opinion that further expansion is necessary in order to improve the competitive position of Taiwan products by lowering the cost of production. However, the future export market is unpredictable and overproduction would not necessarily bring down the cost as long as the old plants are in operation. It is suggested that the inefficient plants be closed down before setting up new ones.

4) Fertilizers on the open market: The barter system is not likely to be abolished in the foreseeable future, but farmers would rather go to the fertilizer dealer and pay a little extra for the fertilizers they prefer. Taking advantage of this situation, quite a few merchants manage to get fertilizers through barter from FAs and resell them on the open market. There are 1,625 fertilizer dealers registered on this Island now. Also, there are about 70 small fertilizer plants engaged in blending various mixed fertilizers having as many as 58 grades. Well-planned regulations governing the manufacturing and marketing of these fertilizers should be enforced.

Table 1. Fertilizer Production and Imports

Unit: M.T.

CY	Production			Imports			
	Gross	N	P_2O_5	Gross	N	P_2O_5	K_2O
1950	58,692	4,180	6,802	231,956	43,803	4,825	2,991
1951	110,381	10,532	10,413	326,077	55,035	5,770	21,129
1952	148,531	14,789	13,451	469,936	78,995	13,381	13,039
1953	163,839	15,846	15,256	348,725	53,847	11,699	20,027
1954	167,800	15,373	16,391	313,465	58,169	6,573	6,498
1955	167,456	15,710	16,023	383,664	62,969	13,665	10,364
1956	192,160	16,367	19,934	381,882	59,979	10,352	19,080
1957	211,215	19,912	20,856	466,562	76,453	10,104	33,790
1958	252,301	28,188	22,489	459,318	77,484	12,897	20,238
1959	288,546	34,109	25,596	471,913	77,368	12,319	29,614
1960	315,141	47,109	25,495	390,350	64,580	5,907	33,333
1961	342,118	52,930	26,287	355,018	59,932	4,881	34,374
1962	423,895	76,310	25,869	303,455	53,715	—	28,184
1963	475,001	81,409	30,989	344,581	60,208	3,510	31,952
1964	670,234	134,834	34,265	205,065	28,671	1,985	39,110
1965	752,062	161,694	37,346	294,314	42,022	—	55,460
1966	766,109	162,569	40,314	270,489	41,693	—	42,542
1967	831,175	176,211	40,042	203,765	24,302	—	52,476
1968	919,238	196,516	40,711	294,000	42,000	—	53,000
1969*	1,210,000	277,350	53,400	198,000	21,000	—	58,000

* Estimation

Table 2. Quantity of Fertilizer Distribution

Unit: M.T.

Year	Barter	Cash sale	Total	Year	Barter	Cash sale	Total
1950	231,765	57,764	289,529	1960	405,592	206,454	612,046
1951	279,857	88,654	368,511	1961	572,916	120,975	693,891
1952	362,117	108,322	470,439	1962	610,865	112,658	723,523
1953	378,363	111,561	489,924	1963	616,605	141,480	758,085
1954	460,179	115,197	575,376	1964	689,720	182,079	871,799
1955	442,080	136,539	578,619	1965	599,318	165,907	765,225
1956	490,281	157,254	647,535	1966	682,585	192,727	875,312
1957	492,291	181,017	673,308	1967	703,564	244,119	947,683
1958	500,716	202,011	702,727	1968	699,109	297,000	996,109
1959	498,736	205,554	704,290			(preliminary)	

Table 3. Fertilizer Consumption Per Hectare of Cultivated Land

Year	Total fertilizer consumption (M.T.)				Cultivated land area (1,000 ha)	Fertilizer consumption per hectare of cultivated land (kg)			
	N	P_2O_5	K_2O	Total		N	P_2O_5	K_2O	Total
1953	69,595	25,210	15,228	110,033	872.7	79.8	28.9	17.4	126.1
1954	82,009	27,330	16,704	126,043	874.1	93.8	31.3	19.1	144.2
1955	83,341	29,084	17,369	129,794	873.0	95.5	33.3	19.9	148.7
1956	90,769	30,693	19,487	140,949	875.8	103.6	35.0	22.3	160.9
1957	96,920	31,955	23,582	152,457	873.3	111.0	36.6	27.0	174.6
1958	101,992	34,055	26,722	162,769	883.5	115.4	38.6	30.2	184.2
1959	102,497	33,935	28,821	165,253	877.7	116.8	38.7	32.8	188.3
1960	94,919	27,790	26,585	149,294	869.2	109.2	32.0	30.6	171.8
1961	108,568	33,312	31,873	173,753	871.8	124.6	38.2	36.6	199.4
1962	117,465	31,599	32,430	181,494	871.9	134.7	36.2	37.2	208.1
1963	121,683	33,300	37,100	192,083	872.2	139.5	38.2	42.5	220.2
1964	142,407	38,655	43,259	224,321	882.2	161.4	43.8	49.0	254.2
1965	131,778	33,982	32,073	197,833	889.6	148.1	38.2	36.1	222.4
1966	152,283	36,585	51,178	240,046	896.3	169.9	40.8	57.1	267.8
1967	155,947	38,294	54,630	248,871	902.4	172.8	42.4	60.5	275.7
1968*	170,000	39,000	59,000	268,000	899.9	188.9	43.3	65.6	297.8

* Preliminary figures.

Table 4. Fertilizer Consumption in Selected Countries

Country	Total consumption (M.T.) 1965/66 N	Total consumption (M.T.) 1965/66 P_2O_5 [2]	Total consumption (M.T.) 1965/66 K_2O	1966/67 (preliminary figures) N	1966/67 (preliminary figures) P_2O_5 [2]	1966/67 (preliminary figures) K_2O	Ave. consumption per hectare of arable land (kg)[1] 1965/66 N	1965/66 P_2O_5 [2]	1965/66 K_2O	1965/66 Total
Austria	91,292	118,693	140,918	89,581	115,044	151,686	52.83	68.69	81.55	203.07
Belgium	146,643	130,224	168,568	154,028	146,361	175,085	156.33	138.83	179.71	474.87
Denmark	191,595	127,192	174,839	215,559	125,470	177,311	70.75	46.97	64.56	182.28
France	870,600	1,258,827	969,835	990,000	1,363,822	1,024,298	41.80	60.44	46.56	148.80
Germany, Eastern	421,400	302,500	588,400	450,000	330,000	630,000	84.36	60.56	117.80	262.72
Germany, Fed. Rep. of	873,823	819,124	1,190,255	888,619	791,804	1,076,770	105.87	99.24	144.20	349.31
Italy	461,767	452,645	167,605	475,340	462,784	173,172	30.18	29.58	10.95	70.71
Netherlands	310,827	114,835	136,560	337,397	109,116	130,720	321.10	118.63	141.07	580.80
Norway	62,900	49,900	56,800	61,500	47,300	53,200	74.35	58.98	67.14	200.47
Spain	387,720	305,522	92,117	931,236	273,541	94,031	18.68	14.84	4.47	37.99
United Kingdom	689,700	421,800	436,300	760,400	439,100	455,700	92.01	56.27	58.20	206.48
U.S.S.R.	2,282,000	1,504,000	1,891,000	2,656,000	1,664,000	1,902,000	9.95	6.56	8.24	24.75
United States	4,831,916	3,522,113	2,922,249	5,487,095	3,928,012	3,287,912	26.10	19.02	15.78	60.90
Ceylon	42,479	945	34,422	45,000	1,000	40,000	22.64	0.50	18.35	41.49
China, Rep. of	146,482	37,382	46,254	155,300	36,800	49,800	164.59	42.00	51.97	258.56
India	540,802	134,284	89,631	830,171	274,601	133,666	3.34	0.83	0.55	4.72
Japan	775,000	546,000	607,000	850,000	630,000	640,000	129.08	90.94	101.10	321.12
Korea, Rep. of	201,163	95,179	40,124	239,691	124,796	58,782	89.17	42.19	17.79	149.15
Malaysia	39,500	6,500	15,300	43,500	6,500	17,300	15.70	2.42	6.04	24.16
Philippines	58,000	30,000	50,000	65,000	41,200	55,000	7.31	3.78	6.30	17.39
Thailand	17,917	11,275	4,569	36,000	17,800	5,000	1.59	1.00	0.41	3.00
Vietnam, Rep. of	26,405	55,415	11,122	45,227	24,736	10,505	9.00	18.88	3.79	31.67
Australia	70,000	953,550	62,658	86,000	979,730	79,000	1.97	26.81	1.76	30.54
New Zealand	6,560	345,604	108,166	7,037	309,054	95,164	8.18	430.93	134.87	573.98

1) Arable land includes land planted to crops (double-cropped area counted only once), land temporarily fallow or used as meadow for mowing or pasture, garden land, under fruit trees, vines and fruit-bearing shrubs. Data taken from FAO Production Yearbook, 1966, Vol. XX, Part I, Table 1 "Land Use".

2) Data exclude ground rock phosphate.

Source: FERTILIZERS—An annual review of world production, consumption and trade, 1967. FAO/UN.

Table 5. Prices of Fertilizers in Bags Paid by Farmers in Selected Countries

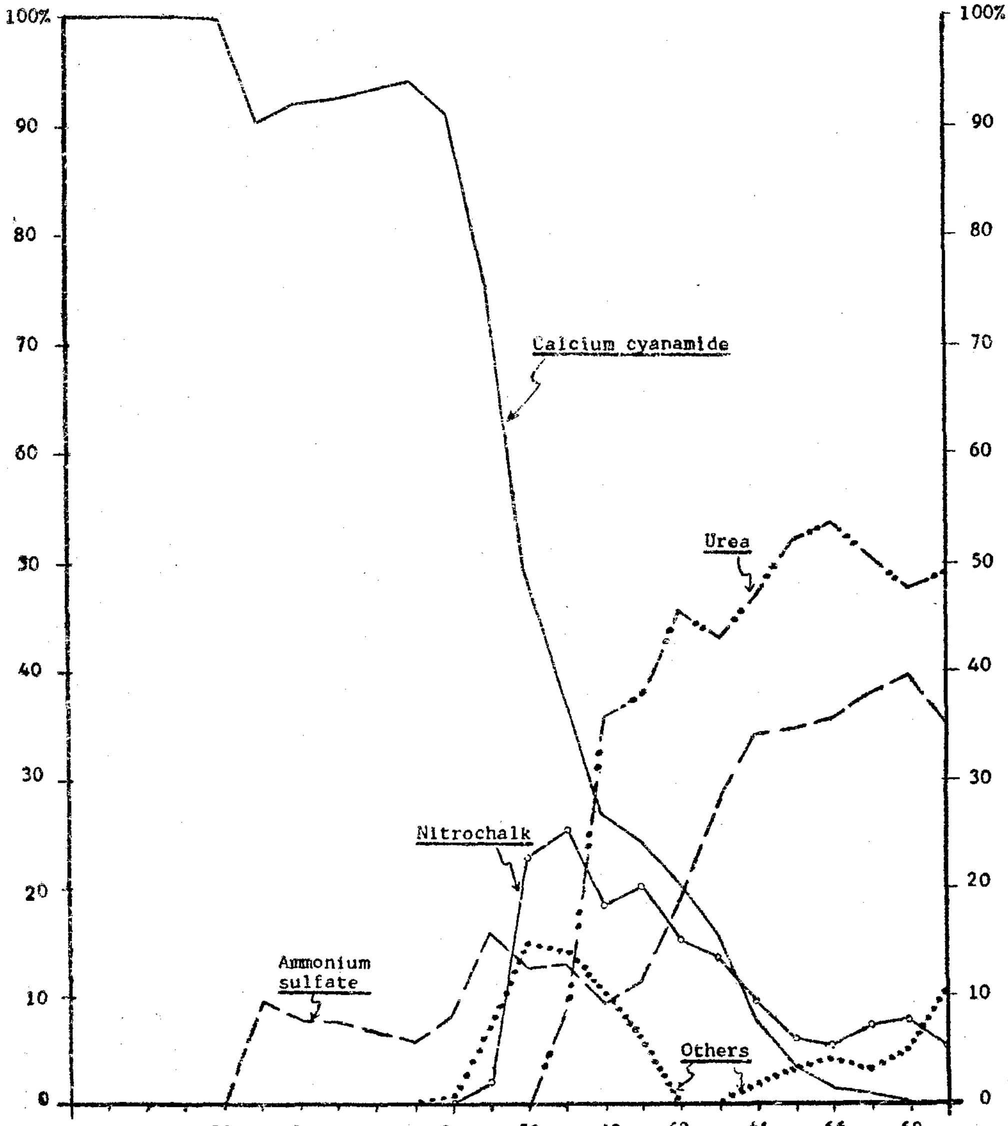
Unit: US$/M.T. of materials

Country	Ammonium sulphate (21% N)			Urea (46% N)			Cal. superphosphate (18% P_2O_5)			Potassium chloride (60% K_2O)			Potassium sulphate (50% K_2O)		
	1961~1962	1964~1965	1966~1967	1961~1962	1964~1965	1966~1967	1961~1962	1964~1965	1966~1967	1961~1962	1964~1965	1966~1967	1961~1962	1964~1965	1966~1967
Austria	54.0	55.6	55.6	—	119.6	119.6	22.9	27.5	27.5	—	46.8	46.8	52.0	60.5	60.5
Belgium	56.3	56.7	47.5	—	107.2	108.6	30.2	32.9	—	49.8[1]	49.2[1]	50.4[1]	54.0[1]	54.0[1]	57.0[1]
Denmark	51.4	53.1	53.8	102.6	87.9	89.2	27.2	29.9	32.4	43.2	46.2	46.8	56.5	61.0	61.5
France	58.4	67.6	68.0	—	—	—	32.9[1]	40.3	41.9	45.0[1]	54.6	54.6	61.0[1]	75.0	74.0
Germany, Eastern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Germany, Fed. Rep. of	55.6	58.8	59.2	112.7	122.4	122.4	36.4	40.9	40.9	42.0	48.0	48.0	46.0	52.0	52.0
Italy	51.0	54.6	57.5	—	—	—	29.7	28.4	30.1	61.2	61.2	61.2	73.5	78.5	85.5
Netherlands	55.2[2]	59.4	58.8	—	—	—	32.6[2]	38.7	42.5	52.8[2]	55.2	56.4	—	—	—
Norway	—	—	—	—	—	—	33.5	23.8	25.7	57.0	69.0[3]	70.8[3]	58.0	—	—
Spain	56.3	62.6[1]	61.5[1]	110.9	120.5[1]	121.0[1]	23.2	29.2[1]	32.8[1]	36.0	44.4[1]	48.0[1]	54.5	56.0[1]	59.0[1]
United Kingdom	30.7	34.2	36.5	—	—	—	20.9	23.9	26.6	63.0	67.3	62.4	66.0	66.0	70.5
U.S.S.R.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
United States[6]	63.6	58.6	59.6	—	115.9	110.9	38.0	40.5	41.8	57.0	64.2	64.2	—	—	—
Ceylon	35.5	47.0	47.0	59.8	73.1	73.1	—	21.8[4]	21.8[4]	43.8	53.4	53.4	—	—	—
China, Rep. of	92.4	92.4	89.7	182.2	164.7	159.6	43.7	42.5	42.5	77.4	75.0	75.0	83.5	75.0	75.0
India	80.6	77.1	79.2[5]	155.5	129.3	132.0[5]	55.6	46.8	48.6[5]	84.0	63.0	61.2[5]	89.0	83.0	81.0[5]
Japan	58.4	55.4	55.4[5]	111.3	111.3	111.3[5]	42.5	41.2	43.9[5]	58.2	58.2	61.2[5]	72.0	69.5	72.0[5]
Korea, Rep. of[7]	65.9	...	56.7	120.1	...	101.2	36.9	...	31.1[4]	58.8	...	51.0	80.5	...	70.5
Malaysia	61.7	...	...	117.3	...	...	53.5	...	...	—	—	—	88.0	...	...
Philippines[2]	46.8	75.2	...	—	—	—	30.4	49.3	...	—	91.2	...	—	—	—
Thailand	50.4	58.6	...	126.5	110.9	...	45.0[4]	37.4	...	81.0	54.0	...	94.5	61.5	...
Vietnam, Rep. of	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Australia	70.4	69.9	59.8	—	119.6	97.1	22.0	14.0	23.2	68.4	67.8	69.6	94.0	88.0	106.5
New Zealand	71.2	81.3[1]	77.7[1]	132.5	101.7[1]	129.7[1]	51.8	19.8[1]	25.7[1]	79.8	69.0[1]	68.4[1]	86.0	99.5[1]	102.0[1]

1) In bulk.
2) Prices at retail store.
3) Converted from potash salts below 45% K_2O.
4) Converted from phosphate over 25% P_2O_5.
5) 1965/66.
6) Average of bagged and bulk prices paid by farmers at varying points of delivery.
7) Calendar year referring to the first part of the split year.

Compiled by JCRR based on data from FAO "FERTILIZERS"
Date: February 21, 1969.

Percentage Changes of N-Fertilizer Production in Taiwan (100% N basis)



THE SIX-YEAR JOINT POTASH PROGRAM IN TAIWAN

Nan-Rong Su

The Background

The maximum consumption of potash fertilizer in Taiwan during the time of Japanese occupation was 10,142 M. T. of K_2O, which was recorded in 1939. It dropped gradually during the war, until it was nil in 1947. The record was broken in 1952 when consumption of the nutrient reached 12,368 M. T.

In 1955, a Taiwan Chemical Fertilizer Field Service was established in Taipei by German and French potash producers for the promotion of potash research and extension.

During its 8-year operation up to April 1963, the TCFFS supported, among others, long-term potash trials for rice and potash experiments for tobacco, sugarcane, sweet potatoes as well as rice on poorly drained soils; and conducted potash demonstrations for rice and upland crops in rotation, and for jute, soybeans and bananas. Chemical studies of soil potassium were made for main agricultural soils, especially concerning the available potassium contents and the potassium economy of paddy soils. Besides, a potassium symposium was held by TCFFS in 1959. Its extension activities also included field-days, distribution of pamphlets and participation in agricultural meetings.

In the meantime, the potash consumption grew from 16,704 M. T. in 1954 to 32,430 M. T. of K_2O in 1962. The work of TCFFS was largely successful, and the almost 16,000 M. T. increase in potash consumption was, to some extent, attributable to its efforts.

However, farmers' understanding of potassium as an essential nutrient was still inadequate as shown in the extremely low resale price of potassium chloride (NT$1.80 per kg compared with the official allocation price of NT$3.00). Should the official allocation of NPK fertilizers in a package deal be terminated, the consumption of potash would drop to a quite low level. It was felt that strengthening of potash extension was a pressing need. Nevertheless, further development of the potash program was handicapped by the limited fund available and the shortage of technical personnel. Upon invitation by the European potash producers, the American potash industries decided to join in operating the potash program in Taiwan.

Establishment of Taiwan Potash Research Foundation

On May 1, 1963, the Taiwan Potash Research Foundation was established in Taichung jointly by the American Potash Institute, Washington, U. S. A., and the International Potash Institute, Bern, Switzerland. The former represented the American potash industries and the latter, the European producers. The TPRF was officially authorized on March 8, 1966 by the Provincial Department of Agriculture and Forestry and subsequently registered in accordance with the Chinese law on May 23, 1966, although its activities were started immediately after establishment.

Policy and Type of Operation

During its 5 years and 8 months of operation, from May 1, 1963 to December 31, 1968, the TPRF successfully expanded the former program of TCFFS, improved the method of extension, participated in the soil fertility research, strengthened cooperation with governmental institutions, and played an active role in all the agricultural meetings and seminars on soils and fertilizers.

The ultimaɟə purpose of TPRF program was to increase the potash consumption in Taiwan by a rational and scientific approach. Application of potash was recommended according to the actual requirements of the soils and the crops, evaluated on the basis of the maximum profit obtainable from such application. In some instances, the rates of potash adopted for the TPRF demonstration plots were even lower than those used by governmental experiment stations in their demonstrations. Emphasis was laid on locating the potash deficient soils and finding the crops or varieties which were heavy potash feeders, investigating the conditions under which the potash effect was likely to be high, and formulating the most efficient method of potash application. In order to be successful in the extension of potash, special attention was directed to studying and teaching the advanced method of nitrogen application.

The TPRF's research and extension program was implemented in four ways, i. e., (1) executing the project by itself, (2) entrusting the various agricultural colleges, experiment stations and improvement stations with the projects, (3) participating in extension activities of the government, and (4) conducting fertilizer demonstrations for the government.

Major Accomplishments of TPRF

A. *Research and experimentation*

During the period of 1963-68, the TPRF conducted researches on soil test evaluation for K problems of rice, sweet potatoes, wheat and sugarcane, studies of critical leaf K levels for sweet potatoes and bananas and some investigations on soil potassium. The researches on soil test evaluation and critical leaf nutrient concentrations called for a number of field trials. In addition, many field trials were made for solving isolated potash problems of 12 kinds of crops.

The total number of the coordinated and isolated experiments (number of sites × number of crops) amounted to 202, of which roughly 50% were on rice, 15% on sugarcane, 15% on sweet potatoes, 10% on bananas and the remaining 10% on wheat, rapeseeds, citrus, forage grasses, peanuts, mustard, Irish potatoes and asparagus.

The most important findings of these researches and experiments were as follows:

1. Soil potassium in general:

Studies of soil potassium conducted at the National Taiwan Uuiversity disclosed that the accumulation and fixation of applied potash were small in amount under submerged conditions, especially in the case of the latosols and sandstone-shale alluvial soils. This implies that the loss of potash fertilizer in the paddy is rapid and thus split application is necessary.

Total K is much more abundant in the finer fractions of any soil than in the coarser fractions, and is the highest in slate alluvial soils, next highest in the sandstone-shale alluvial soil and schist alluvial soil, and very low in latosols.

2. Rice:

1) The critical concentration of exchangeable K in paddy soils of latosol area is 70 ppm. For maximum yield the exchangeable K should be maintained above 90 ppm. From 60 to 100 kg/ha of K_2O is recommended for exchangeable K below 50 ppm, 40 kg/ha for exchangeable K between 50 and 70 ppm, and 0-40 kg/ha for K values between 70 and 100 ppm.

The critical concentration of total K in straw at full-heading stage and at harvest time is 1.7-1.8%.

The critical level of available P in soil by Bray No. 1 method is 15-20 ppm, and by Bray No. 2 method, 30 ppm.

2) Potash fertilizer should be split-applied in the rice paddy rather than applied in one dose as basic dressing. Moreover, a large proportion of it (40-60%) should be applied, for best results, at the time of second weeding (30 days and 20 days after transplanting in the 1st and 2nd crops, respectively). The remainder may be added at the 1st weeding (40%) and/or as basic dressing (20 or 40%).

3) Potash responses of the *japonica* rice varieties are generally larger than those of the *indica* varieties, although in some trials the varieties with a larger number of grains per panicle showed a better response to potash than those with a smaller number of grains per panicle.

4) The red soils which are newly submerged for rice growing respond very remarkably to applications of phosphate and potash, but magnesium sulfate and calcium oxide are detrimental to the yield. In the magnesium trials in old paddies, only one out of the four tested low-Mg soils showed an appreciable response.

5) Potassium sulfate is superior to potassium chloride in a rice field in the coastal area. In fact, an increasing amount of the latter resulted in a decreasing grain yield.

6) In comparison with the conventional practice in which all nitrogen fertilizer is applied to rice during the vegetative growth stage, allocation of 20-30% of the nitrogen fertilizer at 15 days before heading, i.e., the stage of reduction division, produced significantly higher grain yield.

3. Sweet potatoes:

1) Sweet potatoes in most of the tested soils responded to application of potash. The effect of applied potash is well correlated with the available K content of soil tested by the Egner's calcium lactate extraction method used in Europe. The critical concentration of soil available K for this crop is 60 ppm by this method, for both the cal-

careous and non-calcareous alluvial soils. The recommended rates of K_20 are 240, 180, 120, 60 and 0-60 kg/ha, respectively, for the soil test values of 0-20 ppm, 21-30 ppm, 31-40 ppm, 41-60 ppm and above 60 ppm. Where 10 tons/ha of compost is applied, the recommended rate is lowered by 60 kg/ha.

2) Effect of applied potash on sweet potato is exaggerated in the case where frost damage occurs.

3) On a K-deficient soil, application of potash generally gives similar effects, whether it is applied as basic dressing or as top dressings at 30 days and 100 days after planting, so long as the total amounts added are the same. However, the best result is obtained by applying an initial dose of 60 kg/ha of K_2O as basic dressing and a supplement of 180 kg/ha in the later application, provided irrigation is available soon after planting.

4) The critical K concentration in the 4th unfurled leaf from tip was first observed to be 3.3% of dry matter at 30 days as well as at 100 days after planting. More exacting experiments later found that the most economical K_2O rates for top dressing were related to the leaf K levels. Where early irrigation was practised, the economical K_2O rates for top dressing at 30 days after planting were 60, 120, 180 and 240 kg/ha, respectively, when the leaf K values at that time were 4.1, 3.4, 2.7 and 1.9%, respectively. If no irrigation is available in the early stage, the proper top dressing rate of K_2O at 30 days after planting is 120-140 kg/ha for leaf K values below 3.1%. At 100 days after planting, sweet potatoes respond economically to addition of potash at the rate of 120 kg/ha, provided leaf K value at this date is below 3.7%, in the case where potash had been added as basic dressing; and below 3.0%, if no potash was applied as basic dressing.

4. Wheat:

Wheat responds economically to added potash in soils containing less than 45 ppm of Egner's K or less than 70 ppm of exchangeable K. From 0 to 90 kg/ha of K_2O can be recommended, depending on the K status of the soil. As for phosphorus, 75 ppm of Bray's P (No. 2 method) in soil is critical. Also up to 90 kg/ha of P_2O_5 can be recommended, depending on the soil's P status.

5. Sugarcane:

Sugarcane responds to application of potash economically when the exchangeable K level is below 80 ppm in the case of clay-pan soils, and below 70 ppm in the case of podsolic-like soils. Application of 50, 100, 150 and 200 kg/ha of K_2O is recommended for 80, 60, 40 and 20 ppm exchangeable K for acid soils in general. Of the numerous field trials conducted by the Taiwan Sugar Experiment Station, about 1/3 showed yield increase of 10% or higher due to added potash.

6. Banana:

1) Correlation of soil K with potash response of banana is poor. Leaf K value is a much better criterion for the response and non-response of banana to added potash. The critical K concentration in the tissue of the third fully unfurled leaf is 4.75% in late September.

2) The yield of banana fruit proved to be in positive linear relation

with the rate of applied potash up to 600 gm of K_2O per plant or higher when the yield level is maintained above 25 tons per ha. Extra high yield of banana is only possible with extra high potash application.

3) Experiment on the split application of potash proved that early application is preferable to heavy application of potash after shooting for maintaining a high leaf K percentage throughout the growth period of banana plants and for high yield. For the bananas planted in early April, all the potash should be applied by early September (e.g., 25% each in late April and early July and 50% in early September).

7. Citrus:

1) Effect of applied potash on 7-year-old Ponkan (a mandarine) was very marked on a sandy latosol, the yield increase due to addition of 500 gm of K_2O per tree being roughly 40%, exceeding that of the 250 gm treatment considerably. However, the yield increase dropped to 5% in the next year. The juice content of fruit declined and thickness of rind increased in the heavy potash treatment, thus a lighter amount seems more desirable from the standpoint of quality.

2) For the 5-year-old sweet orange (Golden seal), combination of 300 gm N and 300 gm K_2O per plant produced the highest yield and largest number of fruits per tree (P_2O_5 rate was fixed at 150 gm per tree). Interaction between N and K was very pronounced. Increased application of a single nutrient was highly detrimental, while simultaneous increase of N and K rates gave favorable results.

3) For the 6-year-old Ponkan, similar interaction was observed. When N rate was 175 gm per tree, the optimum rate of K_2O was 175 gm per tree, while if N rate was raised to 350 gm, the optimum rate of K_2O rose also to 350 gm.

8. Rapeseed:

1) On soils very low in available K, application of K_2O at 150-225 kg/ha is required for the most profitable production of seeds.

2) According to an NK trial, the most economical rate of K_2O is only 120 kg/ha, when nitrogen is applied at 120 kg/ha, which is insufficient for the improved varieties. However, when the N rate is raised to 160 kg/ha, the most profitable K_2O rate rises to 180 kg/ha.

3) Magnesium sulfate was effective in one of the two K-Mg trials. The effect of applied potash was somewhat greater in the presence than in the absence of added magnesium.

9. Peanuts:

Potash was effective on a sandstone-shale alluvial soil containing 21 ppm exchangeable K, the optimum rate being 40 kg/ha of K_2O. Doubling the amount of application would result in a decline of yield. No effect of potash was obtained on a soil containing 51 ppm exchangeable K.

10. Potato:

Potassium chloride was somewhat more effective than potassium sulfate in increasing the yield of tuber. At 240 kg/ha of K_2O, the yield after the application of the former increased by 62%, while that after the application of the latter increased by 55%. Rotten tuber was less in amount in the case of the chloride. The most profitable rate of K_2O is estimated at 240-300 kg/ha for the low K soils in the potato growing area of Central Taiwan.

11. Mustard:

A mustard trial showed some effect of added potash on the yield (5-7% increase). The effect on quality was reflected in the durability of color of the pickled vegetable. On exposure to the air, the pickles from the potash depleted plots changed quickly from bright yellowish brown to dark brown, while the potash-fed pickles suffered less change in color.

12 Forage grasses:

On two latosols in the North and South Taiwan and on a schist alluvial soil in the East, Pangola, Napier and South African pigeon grasses all responded to increase of N dosage from 150 to 300 kg/ha per annum, while K_2O was needed at 120 to 180 kg/ha on the latosols and 120 kg/ha on the schist alluvial soil.

B. Fertilizer demonstrations and observations

Ten kinds of crop were involved. There were in all 897 demonstrations and observations (or 1,092, if a perennial crop demonstration is counted on the basis of number of years). The crop-wise distributions of these activities are: rice 48%, sweet potatoes 27%, banana 8%, soybean 5%, pineapple 4%, wheat 3%, rapeseed 2%, sisal 1%, cassava 1%, and sugarcane 1%.

1. Demonstrations and observations on K effect or optimum K rate:

All the demonstrations were set up on selected low-K soils according to the soil test.

1) Rice—Various types of demonstrations and observations were conducted for rice. According to the over 300 rice demonstrations, 40-100 kg/ha of K_2O is required in the average soils moderately to strongly deficient in potassium. About 80% of the cases showed response of grain yield to applied potash. The yield increases ranged from 0-30%, but the majority lay between 4 and 15%. The yield response to potash was particularly large in the ill-drained plains of Ilan and Pingtung, showing yield increments of 11-21%. In the Pingtung area, 60 kg/ha of K_2O produced, on an average, 12% more grain as compared to the 30 kg rate.

2) Sweet potatoes—Over 90% of the demonstration fields showed effect of added potash. The yield increases varied from 1 to 200%, with the majority scoring 10-40%. In most cases, 144 kg of K_2O were economically superior to 72 kg of K_2O (higher rates up to 240 kg of K_2O are required in soils highly deficient in potash).

3) Bananas—Effect of potash on banana is remarkable. Besides a 16-50% rise in fruit yield, the percentage of exportable fruit can be greatly raised and the resistance to Sigatoka disease is also markedly increased. Furthermore, the potash-fed banana plants can withstand frost damage better. The optimum doses of K_2O are 450-600 gm per plant per year, or 600-1,080 kg/ha (1,300 plants on slopeland and 1,800 plants in a flat area).

4) Pineapple—Potassium sulfate at the rate of 500 kg/ha of K_2O per crop helped increase the fruit yield by

9% on an average. The increase is highly economical. Degree of response to added K was related to the soil potassium status. There was a frost attack at the early stage of growth in some of the fields and the effect of added potash was then manifest even in a high K soil, because of the stronger resistance of the potash-fed plant to frost damage. Using urea as the nitrogen source, one can obtain similar yield as in the case of ammonium sulfate, provided that the soil is medium to heavy in texture and the cation exchange capacity is high (6-12 m.e. per 100 gm). On sandy soils urea is inferior to ammonium sulfate in terms of unit amount of nitrogen. However, the economic returns are still higher with urea.

5) Soybean—K_2O at 40-80 kg/ha increased yield of soybean by 6-28% on the Pingtung plain, where this crop is grown most extensively. The magnitude of response to potash is not related to soil K, P and pH values within the observed range of variations. It is, however, positively correlated with the level of production, as represented by the yield of the plot receiving complete fertilizer treatment.

6) Wheat—In central Taiwan, where wheat is grown, 45-90 kg/ha of K_2O can raise grain yield by 4-62%, depending on the soil's K level.

7) Rapeseed—Seed yield was increased by 3-69% (average 18%) by applying 100 kg/ha of K_2O. In a few fields 200 kg was significantly more profitable than the 100 kg rates.

8) Sugarcane—Observation plots set up on the plantations of Shanhwa Sugar Mill indicated that potash fertilization was particularly indispensable for sugarcane. Five out of the seven observations (triplicated) showed response to added potash, with yield increases of 13-31%. The optimum rates were 240-300 kg/ha for 4 plantations and 100 kg for another plantation. Nitrogen in excess of 150 kg/ha was not effective for these plantations. Phosphate increased the cane yield by 5.5% on an average.

9) Cassava—In five out of eight fields on the hillside, cassava responded to 100-200 kg/ha of K_2O, with increases in tuber yield of 10-18%, which were highly economical.

10) Sisal—In the main sisal growing area in southern Taiwan, half of the demonstration fields showed pronounced effect of K_2O applied at 100 kg/ha. The increases in fiber yield ranged between 33 and 56% in the second year of harvest. Effect of nitrogen at 100 kg/ha was generally manifest, although there were cases where the no-N plot produced just as much fiber as the N-plot did. Phosphate at 50 kg/ha was also highly beneficial in most cases.

2. Integrated demonstration on the fertilization techniques:

1) Rice—Fertilization techniques alertly adjusted for attaining higher yield were demonstrated for rice at 42 season-sites starting with the second half of 1965 using a single plot, 0.1 ha in size. The basic schedule of fertilization including the NPK rates and their distribution was prepared according to the soil test data, the soil texture and other information. From the grand tillering stage on, the nitrogen application was adjusted alertly in accordance with the reaction of the plant. Split application of potash in adequate amount was also

an important feature. Take 1968 as an example. Yields of grain in the demonstration plots exceeded those of the adjacent check plots of the farmers by 6-44% in the first crop (average, 18%) and 5-27% in the second crop (average, 11%). The highest grain yields attained in the 1968 1st crop were 7.5 tons/ha in South Taiwan, 8.3 tons/ha in Central Taiwan and 5.7 tons/ha in North Taiwan (overall average, 6.7 tons/ha). In the 2nd crop the corresponding figures were 6.6 tons, 7.3 tons and 6.3 tons (overall average, 6.1 tons). The average dosages of N-P_2O_5-K_2O were 101-52-72 kg/ha in the demonstration plots against 103-41-58 kg/ha in the farmers' check plots.

2) Banana—On 40 ha of banana plantations scattered in 23 places, improved fertilization techniques were demonstrated, using 200-100-450 gm per plant of N-P_2O_5-K_2O. The banana yield averaged 23 tons/ha in the demonstration fields and 17 tons/ha in the adjacent orchards, showing a 40% gain. Moreover, most of the fruits produced in the demonstration fields passed the standard for export.

3) Pineapple—Fertilization techniques that involved the use of N-P_2O_5-K_2O at the rates of 660-100-500 kg/ha for the plant crop and 275-0-200 for the ratoon crop, coupled with dense planting and mulching, were demonstrated in 54 ha of pineapple fields in 27 villages. The average fruit yield of the plant crop was 62 tons in the demonstration fields as compared with 26 tons in the check fields, showing a 148% increase.

3. The "Fertilizer Demonstration Village":

In the last two years of TPRF operation, an attempt was made, with government financial support, to impart the knowledge of improved fertilization techniques to farmers in two selected farm villages through seasonal farm seminars, monthly evening classes and closely supervised field exercise in crop fertilization in a large area of land (25 ha in Chichi and 40 ha in Minghsiung), as well as through field days. Farmers were only persuaded to follow the flexible recommendations which were based on soil tests, crop requirement and environmental factors. The principle was to allow them to learn through both success and failure.

In Chichi, a 35% rise in the yield of rice was scored as a result of one and a half years of extension work. Banana yield was up 33%. Fertilization techniques for other crops in the area were also improved. In Minghsiung, the yield of rice and the net profit of production increased by 21% and 25%, respectively, after half-year's extension.

C. *Extension activities*

Proper rates and methods of potash application for different crops and soils were made known to farmers, farm advisors and agricultural officials through field days, lectures, village classes, official meetings and publications. Actually nutrients other than potash and problems other than fertilization were frequently treated in the extension work of TPRF. In many cases, much more time was spent in teaching the intricate techniques of nitrogen application than for potash.

1. Field days:

All field experiments, observations and demonstrations that were successful were used as a tool for extension through the organization of field days. In order to impress the farmers with the treatment effects and the profitableness of the treatments, a yield-estimation contest was sometimes organized on the spot. In all cases field observation was always followed by a straight-to-the-point talk on the reason and method of fertilization.

In all, 428 field days were organized with 32,000 farmers attending. TPRF also participated regularly in the government-sponsored field days upon invitation.

2. Fertilizer lectures:

TPRF agronomists took an active part in giving lectures at the fertilizer seminars held by the Provincial Department of Agriculture and Forestry, the Provincial Food Bureau, the Provincial Farmers' Association and the various township farmers' associations for the extension advisors at all levels and soil and fertilizer workers of the agricultural improvement stations. Lectures were also given annually at the Seminar for the African Trainees. The topics covered techniques of fertilization for individual crops, soil fertility, as well as general soil and fertilizer problems. The number of lectures was 15 in 1963, 22 in 1964, 33 in 1965, 51 in 1966, 45 in 1967 and 43 in 1968 totaling 209. Besides, there were at least 20 talks at the farmers' village meetings each year.

3. Fertilizer extension centers:

With a view to accelerating the use of potash through aggregate extension measures, some model townships where potash consumption was believed to be markedly lagging behind the crop requirement, were selected as extension centers; and knowledge of potash was channeled simultaneously through fertilizer seminars, meetings of farmers study groups, demonstrations, experiments and field days.

With the help of farmers' associations, three centers were maintained for two years and another three for one year, before the termination of TPRF. In the townships where the centers had been set up, the farmers' knowledge of fertilization, particularly of potash application, showed significant improvement, resulting in the sizable increase of potash consumption.

4. Participation in civil and academic meetings:

TPRF was invited to the official meetings for the planning and/or evaluation of fertilizer experiments and demonstrations, and also to the joint annual meetings of agricultural science societies. The total meetings attended were 2, 5, 6, 12, 11 and 14 in the respective years from 1963 to 1968.

5. Publication and distribution of extension and technical materials :

Numerous types of leaflets and lecture materials on experimental results and techniques of crop fertilization were distributed in seminars, field days and village meetings, and many articles were published in extension magazines. Various technical booklets and periodicals donated by the potash organizations abroad were also distributed to research and extension workers.

6. Technical reports:

Besides publishing extension articles, the staff of TPRF were encouraged to compile technical papers on the results of their study on soil fertility and crop fertilization and to present them to the annual meetings of the Society of Soil Scientist and Fertilizer Technologists of Taiwan. From two to four papers were presented annually, and three were awarded as the best paper of the year. They dealt with the soil test evaluations for latosolic paddies and sweet potato soils, and a fertilizer trial for rapeseed.

Influence of TPRF

A. On agriculture

As a result of TPRF operation and its efforts, fertilizer extension in Taiwan was accelerated. Not only the importance of the nutrient potassium was implanted in the mind of farmers and agricultural workers, but new knowledge of fertilizer use was propagated among them through the TPRF activities. Thus the significance of its influence on the promotion of agricultural production in Taiwan cannot be neglected.

B. On potash consumption

The consumption of potash climbed steadily in Taiwan after World War II, owing to the efforts made by the government as well as by the Taiwan Chemical Fertilizer Field Service mentioned before. The effect of TPRF program is reflected in the much steeper rise of potash consumption, starting from 1963. Whereas the K_20 distribution in 1962 (the year before establishment of TPRF) was only 32,430 M. T. or 37 kg/ha, it reached a total of 62,819 M. T., or 70 kg/ha in 1968 (the last year of TPRF operation). The average annual increment in K_20 consumption during the 6-year program of TPRF was 5,065 M. T., as compared with 1,966 M. T. per year during the TCFFS operation and 2,386 M. T. per year during the seven years before TCFFS operation (1947-1954).

Although nitrogen consumption in Taiwan climbed rather rapidly (117,465 M. T. in 1962; 174,403 M. T. in 1968), and the consumption of P_20_5 grew to some extent (31,599 M. T. in 1962; 40,465 M. T. in 1968), their rates of increases were still behind the potash consumption. The consumption ratio of $N:P_20_5:K_20$ was 1:0.27:0.28 in 1962 (when K_20 consumption for the first time exceeded that of P_20_5) and 1:0.23:0.36 in 1968.

C. On price of potash fertilizer

The official allocation price of potassium chloride has been NT$3.00 per kilogram since 1962. Because of the NPK package deal in the allocation of fertilizers, farmers have to take also items which they do not want, so some of them appear in the resale market at a price lower than the original allocation price. In 1962, the year before initiation of TPRF activities, the resale of potassium chloride was as low as NT$1.80 per kg. It rose to NT$1.80-2.40 per kg in 1964, and reached or even exceeded the official allocation price of NT$3.00 in 1965. From that year on, the resale price has fluctuated between NT$3.00 and NT$3.40 per kg, depending on seasons and localities, but never dropped below the official price.

Termination of TPRF

Owing to the steady slump in potash price in the international market during the last few years, the American Potash Institute and the International Potash

Institute could no longer support the potash program in Taiwan. Therefore, the TPRF ceased to function from December 31, 1968.

Unfinished Tasks

The past endeavor of TPRF was concentrated on the western and northeastern parts of Taiwan. Work on the east coast is still to be started. There is also lots of work to be done in the slopeland areas where fertilizer application is far from adequate. A large portion of bananas planted on the slopeland of Central Taiwan is potash-deficient. Potash extension should cover areas of higher elevations, where the production of deciduous fruits is being further promoted. And forestry fertilization has not yet been initiated.

The fertilization technique demonstrations for rice and the fertilizer demonstration villages initiated by the TPRF are being continued by government institutions. The application of simple leaf K test as a tool for promoting the use of potash has just been started.

There is, indeed, plenty of room for developing potash extension in Taiwan. It is expected that potash consumption will eventually reach 100,000 M. T. per year.

SOME PROBLEMS OF LAND USE IN TAIWAN

Lien-Chih Hsi

Introduction

This report is intended as an attempt to identify some of the problems currently encountered in the improvement of land use in Taiwan. As these problems are so complicated in nature that many bear socio-economic implications, the discussion that follows can only be superficial and is from a layman's point of view. No solution, therefore, is offered except for some very broad and immature conceptions.

Present Land-Use Condition

A. Surface features

Table 1 shows the surface areas of major land-form types of Taiwan. Generally, the so-called "mountain land" refers to the combined area of mountains and hills, which totals 25,164 km^2. To be accurate, however, the term "sloping land" should also include such land types as reef limestone, sand dunes and terrace scarps. Thus, the total area of slopeland amounts to 26,042 km^2, making up 72.41% of the aggregate land area of Taiwan.

Alluvial plains and basins, Pleistocene tablelands and diluvial terraces, totalling 8,611 km^2, representing nearly level to gently sloping lands may be considered as arable.

Major land-use types as registered

Table 2 is compiled from the Taiwan Agricultural Yearbook (1968 ed., PDAF) showing the registration of land-use by major types. It can be seen that in 1966 the total registered acreage of cropland (paddy and upland) was 848,494 ha, but 86.58% of the government-owned land had not yet been registered and its use was not given.

C. Acreage of cultivated land

Reports on the acreage of cultivated land were rather confusing which may be cited as follows:

1) Official statistics (PDAF Agricultural Yearbook and PFB Food Statistics) cited the total area of cultivated land in 1966 as 896,347 ha which was inconsistent with the registered cropland area (Table 2), being 5% higher or 47,853 ha more than the latter (illegal farming ?).

2) According to the Land-use and Forest Resources Survey of the Island of Taiwan conducted by JCRR with photogrammetric techniques during 1954-55, the total cultivated area in 1954 amounted to 1,004,600 ha. The corresponding figure given by the official yearbooks was 866,276 ha (including off-shore isles but excluding Penghu) which was about 140,000 ha less than the former.

3) In 1967, a similar survey was made in Hsinchu and Miaoli with aerial photos taken in 1965 covering lands below 1,000 M in elevation. Results were presented in Table 3 together with the

official statistics for comparison purposes. The investigation indicated that the area actually under cultivation in the two counties was 40% or 34,076 ha more than the area reported in the Agricultural/Food Yearbooks.

D. Possible distribution of cultivated land

1) It has been pointed out that with respect to the land-forms, the estimated total area of arable lowland is around 860,000 ha.

2) In regard to present land use (Table 2), it seems reasonable to assume that (a) all the farm/fish ponds and salterns, totalling 26,906 ha, and (b) at least 3/4 of the land used for urban buildings, cemeteries, transportation and irrigation/drainage facilities, and dikes and parks, totalling 170,603 ha, are found on the arable lowlands.

3) From (1) and (2) above, it may be deduced that of the arable lowland, not more than 710,000 ha is now available for crop production.

4) Assuming that 30,000 ha of the existing agricultural land was reclaimed from old riverwashes, then, out of the 896,347 ha of total cultivated land, at least 156,000 ha must be located in slopeland regions.

5) If the figure of 1,004,600 ha reported by the Land-use Survey is accepted as the cultivated land area of Taiwan Island, the total acreage of slopeland farming would be some 300,000 ha. Most likely the area has been expanded considerably during the past 15 years.

E. Shifting use of agricultural land

Table 4 is the summary of a survey conducted by the Taiwan Sugar Corporation in the sugarcane-extension region covering 433,564 ha. It shows that during the one year period under study, a total of 5,060 ha (including 2,794 ha of paddies and 2,266 ha of upland) of good agricultural land had been turned into building sites, which was only partially offset by 1,653 ha of much inferior land reclaimed from the wasteland. In other words, the region suffered a net loss of 3,783 ha of cropland within one year (0.8% per annum), not to mention the detrimental effects of such uncoordinated shift on the infrastructures built through the years.

Land-use Problem

The agriculture of Taiwan has advanced to the stage where many problems stand in the way of further progress, and the most intricate ones are unexceptionally related to the existing policies and institutions which seem beyond the scope of this report. Only some factual points relevant to land features, techniques and/or farmers themselves will be mentioned.

A. Concerning soils

Some 250,000 ha of agricultural lands in Taiwan are plagued by various soil problems. They include some 50,000 ha of dense clay (kan-tien-tin), 40,000 ha of saline sands, over 30,000 ha of loose gravelly soils, around 120,000 ha of acid clayey red soils, and at least 50,000 ha of very poorly drained alluvial soils. Besides, about two-thirds of the 300,000 ha of cultivated slopelands are subject to active erosion. It may be said that farming on almost one-half of our agricultural lands is handicapped by inherent soil problems and/or mismanagement.

B. Concerning climate

Taiwan is bestowed with a year-round growing season for most economic crops in the lowland areas. However, the climate is not close to the optimum for human energy which is assumed to embrace cool winters of around 5°C and mild summers averaging in the neighborhood of 18°C. The corresponding figures for Taiwan are approximately 15° and 28°C, indicating a climatic setting more favorable for plant growth than for human physical and mental processes. Besides, the high relative humidity may also have an adverse effect on human activities.

Another significant point is that the low mean temperature at high altitudes does not signify a similarity between the mountain climate and the climate of a temperate zone in so far as the amount and distribution of rainfall, cloudiness and photo-period are concerned.

C. Concerning water

Many of the existing canals or reservoirs in Taiwan deliver very little water, or none at all to the farms during the long dry season, thus limiting the growth of winter crops. And the construction of new irrigation works would probably be too costly for the production of most field crops. How to make efficient use of the limited water supply would thus pose a pressing problem when the use of a considerable portion of our fertile soils is being intensified.

D. Concerning crops

Taiwan's climate is primarily of the tropical/subtropical type. To be sure, the most promising crops and cropping systems suitable for commercial production are those which originate from or are common in such geographic regions. However, the idea of "self-sufficiency" means a much intensified and diversified agriculture for the whole Island. This concept has made it necessary for our crop scientists and horticulturists to work with all types of crops in almost the entire range of crop geography. Although we could technically succeed in growing a certain new crop after several years of efforts, eventually it might turn out that either the production cost is too high or some unexpected pathological, physiological or marketing problems have come up to deter the large-scale production of the crop in question.

E. Concerning land-use intensity

While the Government has been trying hard to boost agricultural production by all possible means, there has been a growing tendency among the farmers to fallow their lands, especially the double-cropping paddy fields, in winter in the past few years (Table 5). The reasons are many, but this has more to do with the profitableness of winter cropping in relation to living standard than with technical reasons.

Living standard involves the enjoyment of leisure in addition to material comfort. At the standard of living in Taiwan 15 or 20 years ago, a farmer might expect from his hard work no greater reward than the basic necessities of life. Now he would complain if a certain amount of labor does not result in a liberal margin over and above the basic necessities. Besides, we should not forget that the climate of Taiwan is not ideal for human field activities anyway.

While many of the nation's white-collar workers spend their leisure hours in self-indulgence or just sitting idle, it seems unfair to ask the farmers to do the back-breaking work without an attractive profit.

Orientation of Concept

The situation being such as mentioned above, it would be impossible for any one in any specific field to propose an ideal and workable solution for these problems. However, there are some premises which, as I can see, may have an important bearing on our attempt to improve the land-use patterns for increasing agricultural production in Taiwan.

A. *Intensive management vs. extensive farming*

Intensive agriculture calls for large amounts of investment and high-level techniques. It is generally the case under favorable natural and economic conditions, i. e., in places where the unit production is high with a dependable market. On the other hand, extensive farming requires much less investment. Thus, the production cost would be comparatively low. Although the unit yields are usually low, it may still be profitable under certain conditions.

As the farm size of Taiwan averages only a little over 1 ha, it seems necessary that every piece of land be cropped intensively. Unfortunately, the fact is that high unit yield does not always mean more profit, owing to the high cost of production incurred by intensive management.

Then, what should we do, intensive or extensive farming? To find the answer to this contradictory question, we should be aware of the fact that to learn to live with nature is much simpler than to fight against it. A two-way approach is thus suggested: Good fertile lands and adaptable crops offer a great opportunity for large investment; while on poor soils and for crops which are not native or not so adaptable to the local environments, extensive agriculture might be a better choice.

B. *Specification vs. diversification*

In planning the land use pattern for a farm or an area, one of the early steps to be taken is to decide whether emphasis should be placed on specialized production or a diversified system. Although the general trend throughout the world is to develop from sustained farming toward commercialized production, there are both advantages and disadvantages involved in the two types of agriculture.

A diversified system can make rational use of farm resources—land, labor, equipment and capital—and produces all the necessary food to the satisfaction of farm life. It is commonly tied up with sustained farming on small holdings where short-term crops are most likely raised. Although the profit potential would be rather low, it always leaves the farmer with something to fall back on in case of crop failure or disastrously low price of farm produce. A well operated diversified farming system with compatible crops and livestock can not only make full use of the family labor, but may also bring additional cash income.

In the case of specialized enterprise, all facilities, supplies and technical and managerial efforts can be orderly organized for the production of a single crop. The quality of the product as well as the cost may readily be controlled. The potential profitability is generally higher in normal years, but the risk elements involved would also be larger. The system is better suited for farmers with enough financial resources and in areas where the physical and socio-economic factors are favorable and the marketing of the products is well organized.

In selecting a type of farming for a certain area, both the objective and the subjective factors involved must be weighed carefully. As Parker pointed out, "The initial decisions regarding land use and cropping pattern will be based principally on physical and biological considerations. Once the field has been narrowed to agronomically feasible cropping alternatives, the optimum choice should be based upon economic analysis."

It seems desirable that, at least in the aboriginal and the mountain regions of Taiwan, the diversified farming system should be encouraged.

C. Widely adaptable varieties vs. high-yielding ones

It is true that high-yielding varieties of crops offer a much better chance for successful farming. However, many of the so-called improved varieties require good soils, heavy fertilization and intensive management or even special cultural techniques. They may also be more susceptible to moisture stress and insect or pest damages, while some inferior or low-yielding varieties can thrive in adverse environment. One good example is NCO-310, a thin stalk variety of sugarcane, which can seldom yield more than 150 MT/ha of cane even under very intensive husbandry on fertile soils while some improved varieties may produce 250 or 300 MT under similar conditions. But on the sand and/or gravelly soils without irrigation, NCO-310 can give much better performance than the others.

Experience in aborigines reservations has shown that some of the new, improved crop varieties, which produced 20-30% higher than the native varieties on advanced farms, yielded even less than the native ones. It is suggested that, for the underdeveloped areas, widely-adaptable crop varieties which can thrive quite well on poor soils under less favorable conditions should be preferred to the improved high-yielding but rather delicate ones. Selection of such varieties is, therefore, considered desirable at least during the initial stage of development.

D. Irrigated agriculture vs. dry farming

The high temperature throughout the year, uneven distribution of rainfall and the high rate of evaporation in Taiwan, especially on the coastal plains, all point to the need for supplemental irrigation in a successful agriculture. Water has been generally considered as one of the factors limiting the further increase of crop production. Some has gone so far as to advocate the expansion of irrigation as a pre-requisite for slopeland development. However, as the water resources have been developed to the stage that any further increase of irrigation, either in capacity or in intensity, would be very costly. With the construction cost soaring and the price of farm products staying low, it appears unlikely that irrigated farming can be extended significantly in the foreseeable future in Taiwan except for the Chianan plain which lies in the Tsengwen Project area.

Such being the case, I cannot help wondering if we could further increase the per unit crop yield through the improvement of cropping systems as well as cultural techniques under rain-fed conditions. A careful study of the past climatic records leads me to believe that, at many places, there might not be very serious moisture shortage for a long time in so far as many of the common dryland crops are concerned. Thus the development of suitable dry-farming techniques should be further stressed.

Table 1. Surface Area of Landform Types of Taiwan

Landform type	Area (km²)	%
Mountains	22,986	63.92
Hills	2,178	6.05
Reef limestone	140	0.39
Sand dune	129	0.36
Tableland scarp	609	1.69
Tableland gravel	1,196	3.33
Diluvial terrace	552	1.53
Alluvial plains	6,863	19.09
River waste	1,308	3.64
Total	35,961	100.00

After W. Rhynsburger, MSA/C, 1953.

Table 2. Registered Land-Use Categories of Taiwan (1967)

Unit: ha

Land-use	Land classification		
	Registered		Non-registered public land
	Private	Public	
1. For direct production	922,391	272,525	
Paddy	(480,003)	(48,890)	
Upland	(232,392)	(87,209)	
Timber, pasture, mines	(196,088)	(123,428)	
Ponds and saltern	(13,908)	(12,998)	
2. Built-on/cemetery	49,627	30,803	
3. Transportation/irrigation	32,176	12,397	
4. Dike, park, etc.	15,489	30,111	
Total	1,019,683	345,836	
Grand total	1,365,519		2,230,602
Aggregate land area	3,596,121		

Source: Taiwan Agricultural Yearbook, 1968.

Table 3. Cultivated Land Area in Hsinchu and Miaoli in 1965

Unit: ha

County	As reported by PDAF/PFB			As shown by aerial photos		
	Paddy	Dryland	Total	Paddy	Dryland	Total
Hsinchu	20,715	22,027	42,742	32,498	22,909	55,407
Miaoli	21,572	19,735	41,307	31,111	31,607	62,718
Total	42,287	41,762	84,049	63,609	54,516	118,125

Table 4. Changes in Land Use in the Sugarcane-extension Area* from July 1967 to June 1968

Unit: ha

Land-use type	1967 cultivated land	Change during the period				1968 cultivated land
		Gain from		Loss to		
		Land reclamation	Conversion of upland/paddy	Building site	Upland crops or paddy	
Paddy	335,694	350	3,662	2,794	121	336,791
Upland	97,870	1,303	121	2,266	3,662	93,366
Total	433,564	1,653	3,783	5,060	3,783	430,157

* Covering Hualien and Taitung in East Taiwan and the counties/cities south of Taichung in West Taiwan.

Source: TSC survey.

Table 5. Acreage of Winter-fallow Land in Taiwan in 1964/65

a. by causative factor

Unit: ha.

Causative factor	Double-cropping paddy land	Single-cropping paddy land		Dryland	3-year rotation land	Total
		1st crop	2nd crop			
1. Cutting-off of irrigation during winter	22,481	711	6,981	743	255	31,171
2. Out of irrigation area	2,480	1,442	4,661	17,360	—	25,943
3. Fallow period too short	12,420	1,541	23,696	10,381	—	48,038
4. Low temperature	4,625	1,762	312	2,468	—	9,167
5. Wetness	11,271	624	180	446	—	12,521
6. Strong monsoon	7,682	1,096	1,923	1,516	—	12,217
7. Late harvest of 2nd rice crop	8,645	—	582	7	—	9,234
8. Shortage of labor	24,787	387	325	1,325	—	26,824
9. Unfamiliar with winter cropping	17,544	165	333	1,249	—	19,291
10. Lack of capital/incentive	6,167	279	6	—	—	6,452
11. Damage by livestocks	984	61	—	65	—	1,110
12. Others	5,108	4	844	370	217	6,543
Total	124,194	8,072	39,843	35,930	472	208,511

b. by county

Unit: ha.

County	Land type						Total cultivated land	% fallow	Dominant restricting factors for winter cropping
	Double-cropping paddy land	Single-cropping paddy land		Dryland	3-year rotation land	Total			
		1st crop	2nd crop						
Ilan	17,905	480	—	884	—	19,269	28,203	68.33	Wetness
Taipei	17,187	3,507	366	3,748	—	24,808	53,754	46.15	Low temperature and strong monsoon
Taoyuan	28,437	25	—	1,620	—	30,082	55,571	54.13	Shortage of labor and irrigation
Hsinchu	10,645	1,313	—	4,037	—	15,995	42,180	37.92	Lack of irrigation, labor-shortage
Miaoli	3,062	1,194	—	2,294	—	6,550	41,550	15.76	Lack of water (rain-fed)
Taichung	5,206	—	7	1,724	—	6,937	55,533	12.50	Lack of water, short season
Changhua	8,742	—	227	307	—	9,276	76,507	12.13	Labor shortage, insufficient water
Nantou	2,318	—	1,096	611	—	4,025	50,356	8.00	Lack of water
Yunlin	7,114	—	18,788	3,485	119	29,506	86,462	34.13	Short season
Chiayi	5,029	61	10,031	3,152	57	18,330	71,047	25.80	Short season, insufficient irrigation
Tainan	2,820	103	4,705	5,102	297	13,027	104,288	12.49	Short season, lack of water
Kaohsiung	5,268	471	3,514	2,789	—	12,042	59,883	20.11	Lack of water, late-maturing of 2nd rice crop
Pingtung	2,746	71	408	1,294	—	4,519	78,143	5.78	
Taitung	5,481	403	304	2,633	—	8,821	36,222	24.35	Short fallow season, lack of water
Hualien	2,233	444	396	2,251	—	5,324	33,247	16.01	
Total	124,193	8,072	39,842	35,931	473	208,511			

WORK PROGRESS OF THE SAND SOIL DEVELOPMENT PROGRAM

Lien-Chih Hsi

I would like to make a brief report on the underground barrier tests for the reclamation of sand soils being conducted along the west coast under the supervision of PID. During the past few days, you gentlemen probably all have read quite a bit about this subject in local newspapers. I am afraid that it has been publicized too much. The story has been told by the newsmen beautifully. They have exaggerated the results by putting all emphasis on yields but failed to look into the technical and economical problems involved. Sometimes we found that the reports were even confusing or misleading. In one paper published in central Taiwan, it was reported that the experiment in the Lintsuliao area was initiated and carried out exclusively by the Reconstruction Bureau of the Yunlin County Government. As a matter of fact, the Magistrate, Mr. Liao, never bothered to take a look at it until PDAF Commissioner Chang visited the plot in early June 1968, and then the Bureau Chief came to the spot only to show up before Governor Huang's inspection party at the end of June 1968. Yet they try to claim all the credit. Besides, the newspaper mentioned cantalops and flowers. In fact they can be grown on genuine sand soils with special management, and they have nothing to do with the PE barrier. I wish to take this opportunity to explain the situation briefly so that you may have a true picture of this much publicized program.

While the preliminary trials made in Tainan, Yunlin and Hsinchu so far have all demonstrated that, by installing an underground barrier at appropriate depth, it is possible to grow good crops of rice on saline/sand soils with reasonable amounts of irrigation water and fertilizers, there still remain a number of problems which need to be solved before the program can be expanded for large-scale implementation.

Above all, the economy of the reclamation practice should be studied and analyzed in detail. As you may know, we started the test by placing a hot asphalt layer on the bottom and sides of a pit properly dug, and then replacing the soil removed all with manual labor. The cost ran up to nearly US$4,000/ha. Dr. A. E. Erickson, Professor of Soil Physics, Michigan State University, who devised the asphalt technique, estimated that by using a specially designed asphalt applicator hauled by a heavy tractor, the work can be done at a cost of about US$700/ha. However, the machine would cost some US$50,000 and, with a blade of 10-foot wide, it can work only on larger field, say at least one acre. It is definitely not adaptable to the small farm situation of Taiwan. We tried to use cold asphalt emulsion instead of hot asphalt, which is rather difficult to handle with manual labor, for making the barrier in the Hsinchu polder last winter. Unfortunately, due to some technical reasons, the emulsion prepared by the United Industrial Research Institute did not come up to our expectations. And polyethylene sheet is considered the only material available for the present purpose.

To compare the effectiveness of various materials, two small plots each of asphalt, pitch and PE sheet barriers were laid in the Lintsuliao Rural Development District last year. To prevent leaking, the PE sheets were joined together before being laid down in the field. The PE barrier turned out to be the best so far as water retention is concerned. However, we found that it would be very difficult to handle a large-sized plastic sheet in the field, especially in the windy coastal areas. Meanwhile, from this test we figured that some 40-50 man-days were required to dig and remove the dirt from a plot of 0.1 ha to a depth of 50 cm, and it would take another 30-40 man-days to backfill the pit after the barrier is put on the bottom.

In an attempt to reduce the labor cost, we made tests on several large plots, 30 m × 34 m, using separate sheets having an overlap of 25 cm on each side in Lintsuliao this year. Excavation and placing of the PE sheets were done section by section successively so that the first section could be filled with the earth dug out from the next section after the sheets had been put down properly. This overlapping increased the area of sheets required by about 13%. There would be a chance of leaking along the sides. However, it is believed that after filling, the amount of water seeping through the tightly overlapped edges would be so small as to be negligible. On the other hand, by combining digging and filling into one operation in such a way, we were able to install the PE barrier at 50-cm depth with less than 400 man-days/ha. The cost of PE sheet (2-meter wide) is estimated at NT$25,000 to 28,000. If wider PE sheet, say 4 m in width, is available, the cost could be further lowered. It is hoped that, if the total initial cost can be cut down to somewhere around NT$40,000/ha., the farmer may be able to install the barrier all by themselves, provided that long-term low-interest loans for the material could be made available by the government.

However, there are some other technical problems which call for further studies such as:

1) How long would the barrier last under paddy as well as dryland conditions?

2) Is it possible to develop a compact layer or some sort of a pan just above the barrier after continuous cultivation of rice for a number of years? Should it be the case, the installation of a barrier would be a lasting treatment for the reclamation of sand soils.

3) What would be the changes in soil properties which might develop above the barrier?

4) What are the effects of underground barriers on the development of root systems as well as on the types and activities of micro-organisms, especially under paddy conditions?

5) Can this technique prove equally useful on droughty sand soil in areas where the irrigation water is not available or in short supply?

We are now working on these problems both in the field and in the laboratory. It will take some time before any conclusive results can be obtained. These are the reasons why we have been reluctant to have this program much publicized at this moment.

IMPROVEMENT OF LAND UTILIZATION AND WINTER CROP PRODUCTION

Yung-Chun Lo

Fuller Utilization of Land

The cultivated area of Taiwan in 1967 was 902,407 ha, representing 25 percent of the total land area of the island. Of this amount, 60 percent was paddy field and the rest, dryland. This rate has remained largely unchanged in the past 30 years, signifying that it is difficult to expand the planting acreage, particularly the paddy land. Despite the government's investment in opening up new land and water resources, more and more farm land has been used as sites for factories, houses, roads and public utilities. According to a survey made by the Food and Agricultural Economies, a private monthly publication, within ten years from 1957 to 1967 some 6,000 hectares of paddy land was converted into industrial sites, not to mention the land used for other purposes.

In 1967, the planted area of all crops except green manure crops was 1,822,588 hectares with a multiple cropping index of 201.97. Taichung and Kaohsiung cities are rated the highest in land utilization with a multiple cropping index of above 250. Taichung, Changhua and Pingtung counties where larger areas of paddy land are used for growing short-season and winter crops extensively are next, with a multiple cropping index of over 230. Penghu county, where only a single crop can be raised in a year because of strong winds, has the lowest rating, its index being 129.65. If classified according to cropping seasons, the multiple cropping index of winter is 76.32, spring, 102.73, and fall, 102.03. The practice of interplanting accounts for the high index in spring and fall, and the low index in the winter is due to the fallowing of over 210,000 hectares in that season.

As to land utilization in different seasons, there is only a limited area of paddy land in northern Taiwan and the dryland crops there consist mainly of tea and fruits with very little winter cropping practised. The Chia-Nan area has a vast area devoted to growing sugarcane and fruits. In East Taiwan, the individual farms are poorly managed and cropping systems crudely followed, accounting for the low multiple cropping index. The annual planted acreage and multiple cropping indices and the indices of 1967 for different areas are given in Table 5 a), b), c).

Factors Limiting Winter Cropping in Northern Taiwan

Factors leading to low utilization of land in the northern part of Taiwan are: 1) strong northeast monsoon is detrimental to crop growth; 2) low temperature starts earlier and time for rice harvest later than in the south, thus affecting the timely planting of winter crops; 3) labor shortage as rural youths are being absorbed by industrial plants; 4) the dry season starts one month earlier than in the south and irrigation facilities are lacking in many places; and 5) the abundant rainfall in the spring affects the harvest of crops.

According to a survey made by the Hsinchu DAIS, in 1962 the land utilization rate in the Hsinchu area was 30 percent. After extension of the relay interplanting method to stabilize crop production in 1963, the rate was increased to 55 percent. But then a number of new limiting factors such as the slump in the price of rapeseed, relaxation of import control on corn and wheat, and worsening labor shortage caused the rate to drop to 47 percent in 1967 and further to 44 percent in the following year. Under the circumstances, the expansion of winter cropping area will not succeed unless the farmers can be guaranteed a fair profit from growing crops in winter.

Raising sweet potatoes as hog feed in the winter-fallow paddy fields may be an answer to the question of how to promote winter cropping in northern Taiwan. As a first step, early maturing rice varieties, such as Taichung No. 180, Hsinchu No. 62, Taipei Nos. 310 and 311, and Nunglin No. 39, can be grown. This will be followed by the planting of improved sweet potato varieties like Hsinchu No. 1 and Hung-hsin-wei, with the relay interplanting method also to be improved. In this way, the land utilization rate may be raised to as high as 80 percent, and the planted area of sweet potatoes can be increased by more than 40,000 hectares with an estimated output of over 400,000 metric tons worth some NT$200 million. The extra amount is sufficient to feed some 300,000 hogs valued at NT$700 million.

Most of the drylands in northern Taiwan are tea gardens and orchards and the area available for growing sweet potatoes is very limited. Farmers who raise hogs for additional income have to set aside a part of their paddy fields for feed production. But if the relay interplanting method were generally adopted by the farmers, the estimated 7,000 hectares of paddy land on which sweet potatoes are grown could yield both rice and sweet potatoes. Thus, the rice production can also be increased by 20,000 metric tons worth about NT$-100,000,000.

Table 1. Rate of Land Utilization for Two Crop Seasons in Hsinchu Area

Year	Double cropping field (ha)	Planted acreage of winter crops (ha)						Rate of land utilization (%)
		Vegetables and green manure crops	Relay inter-planting	Rape	Wheat	Others	Total	
1961	80,426	16,669	5,197	1,061	1,456	201	24,584	30.6
1963	78,795	36,398	4,169	1,397	628	577	43,169	54.8
1965	81,567	33,167	3,882	2,241	870	620	40,780	50.0
1966	83,044	30,938	4,128	1,271	1,417	399	38,153	45.9
1967	84,177	32,085	5,187	1,029	1,176	338	39,815	47.3
1968	83,968	29,881	5,358	983	629	196	37,047	44.1

Note: Excluding the area for fall cropping sweet potato, sugarcane and long-term crops.

Table 2. Rate of Land Utilization for Winter in Northern Taiwan[1)]

Year	Cultivated land (ha)	Planted acreage[2)] (ha)	Rate of land utilization (%)
1963	221,954	132,148	59.54
1966	225,523	131,242	58.19
1967	227,913	129,716	56.92
1968	216,623	122,715	56.65

1) Including Taipei, Ilan, Taoyuan, Hsinchu, Miaoli counties, Taipei, Keelung cities and Yangmingshan Administration.

2) Including short-term crops, green manure crops, fall cropping sweet potatoes, sugarcane and other long-term crops.

Proposal for Raising the Productivity of 3-year Rotation Land in Southern Taiwan

Of the 3-year rotation land in the Chia-Nan area, about 70,000 hectares is used for growing the fall crop of sweet potato with about 50,000 ha or 71% of it interplanted or planted after the harvest of the second rice crop. This also represents 40% of the total planted area in the second rice season. Under the existing rotation system, sweet potatoes are planted in early or mid-November after the second rice crop is harvested in mid-October. The harvest of the sweet potato crop takes place in April or May of the next year, and then peanuts, sugarcane, beans or upland rice are planted in June and July. But the total length of time required for growing the sweet potato crop including the time for land preparation and harvest will amount to eight months.

If the fall crop of sweet potatoes were raised by the improved relay interplanting method, the farmers could benefit greatly from it. The advantages are briefly described as follows:

1) The relay interplanting of sweet potato vine cuttings in mid-September will shorten the growth period and the harvesting time can be advanced to February and March to produce about 75% of the same crop as regular plantings.

2) Taking advantage of the abundant rainfall in the spring, jute, beans, peanuts, sorghum, corn or sesame can be grown right after the harvest of relay interplanted sweet potatoes, thus producing an additional profit of NT$7,000-13,000.

3) Crop damage from frost can be minimized, and the potato chips exposed to the sun to dry on the ground will not be subject to rain damage or spoilage before harvest. For example, the long spell of rains in May and June of 1966 spoiled a total of 52,000 metric tons of sweet potatoes valued at NT$35,000,000.

4) During the time of green fodder scarcity in February and March, the prices of sweet potatoes and their vines are usually 10-20% higher than in any other periods.

However, in relay-interplanting sweet potatoes, part of the transplanted rice seedlings must be quickly removed to leave room for the sweet potato vine cuttings, and labor is also required for preparing the beds for the cuttings. In times of labor shortage and during late spring rains, land preparation for the spring crop would be impossible. For solving this problem and facilitating the practice of relay interplanting, mechanization of the whole process to save both time and labor will be necessary. Farmers can also perform winter cropping and spring tillage and irrigation by using mechanical power. Once the power problem is settled, the improved relay interplanting of 10,000 hectares of sweet potatoes on sandy loam or loam in the area with favorable cultural conditions will earn for the farmers a gross income of NT$100,000,000. The contrast between the rotation system and the conventional practice is given in the following two tables.

Table 3. The Proposed Improved Relay Interplanting Method

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Gross income index
1		(1)					(7)								156.7
			(2)									(8)			
2		(1)					(4)								143.0
			(2)												
3		(1)					(5)								139.3
			(2)									(1)			
4		(1)					(4)								167.0
			(2)									(1)			
5		(1)						(6)							179.1
			(2)												
6		(1)					(3)								145.4
			(2)												
Check		(1)													100.0
			(2)												

(1) Rice, (2) sweet potato, (3) corn, (4) sorghum, (5) bean, (6) jute, (7) peanut, (8) sugarcane, miscellaneous crops.

Table 4. The Rotation System Designed and Demonstrated by Tainan DAIS

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Gross income index	Net income index
1	(1)							(4)							119	90
				(3)								(1)				
2	(1)							(5)							112	100
				(3)								(1)				
3	(1)							(6)							145	140
				(2)								(1)				
4	(1)							(7)							110	71
				(3)								(1)				
Check	(1)														100	100
				(2)												

(1) Rice, (2) sweet potato, (3) corn, (4) sorghum, (5) soybean, (6) jute, (7) peanut.

To sum up, in the northern and eastern parts of Taiwan and the Chia-Nan region, land utilization can be improved through extending winter cropping (Table 6) and relay interplanting of sweet potatoes in paddy fields. The first step should be to select those places which are protected from winds and whose soil is sandy loam or loam that can be irrigated. The crop or crops chosen should be those which can be easily cultivated, and their acreage should be gradually expanded. In central Taiwan and the Kaohsiung-Pingtung area where land has been fully used, emphasis should be placed on finding labor-saving cultural practices and producing crops of high economic value. Only after production is stabilized can it be said that the land has been used in a highly economical manner.

Table 5. Planted Acreage, Area of Cultivated Land and Multiple Cropping Index in Taiwan

a) For the period of 1940-67

Year	Planted acreage (ha)										Cultivated land (ha)			Multiple Cropping index	
				Horticultural crops[1]					Total						
	Rice	Common crops	Special crops	Fruits	Vegetables	Total	Other crops	Green manure crops	Incl. green manure crops	Not incl. green manure crops	Paddy field	dryland	Total	Incl. green manure crops	Not incl. green maunre crops
1940	633,642	162,484	357,087	59,061	40,422	99,483	251	192,182	1,445,129	1,252,947	529,610	330,829	860,439	167.95	145.62
1941	646,927	181,254	348,766	60,877	39,264	100,141	237	208,625	1,485,950	1,277,325	527,981	331,465	859,446	172.90	148.62
1942	616,529	188,053	340,701	62,836	42,513	105,349	239	237,892	1,488,763	1,250,871	524,533	329,929	854,462	174.23	146.39
1943	610,051	190,279	295,251	55,540	39,351	94,891	227	236,996	1,427,695	1,190,699	519,861	327,125	846,986	168.56	140.58
1944	600,688	199,363	217,446	53,251	39,102	92,353	217	187,060	1,297,127	1,110,067	501,414	306,751	808,165	160.50	137.36
1945	502,019	161,363	131,867	19,306	35,316	54,622	134	153,886	1,003,891	850,005	504,709	311,307	816,016	123.02	104.17
1946	564,016	213,185	177,804	22,485	40,329	62,814	151	230,405	1,248,375	1,017,970	507,636	324,315	831,951	150.05	122.36
1947	677,558	258,493	278,337	32,391	57,110	89,501	542	179,287	1,483,718	1,304,431	516,378	317,573	833,951	177.91	156.42
1948	717,744	287,463	342,103	35,357	59,662	95,019	754	265,917	1,709,000	1,443,083	526,384	336,773	863,157	197.99	167.19
1949	747,675	301,644	327,526	33,220	68,220	101,420	754	216,420	1,695,439	1,479,019	528,097	336,767	864,864	196.04	171.01
1950	770,262	308,193	307,160	32,162	74,299	106,461	754	198,621	1,691,451	1,492,830	530,235	340,397	870,632	194.28	171.47
1951	789,074	307,526	349,443	32,620	78,602	111,222	754	202,949	1,760,968	1,558,019	533,803	340,067	873,870	201.51	178.29
1952	785,730	314,637	361,740	37,529	77,277	114,806	952	207,103	1,784,968	1,577,865	533,643	342,457	876,100	203.74	180.10
1953	778,384	319,845	328,899	34,865	77,155	112,020	2,276	192,269	1,733,693	1,541,424	533,316	339,422	872,738	198.65	176.62
1954	776,660	337,140	333,936	34,486	79,001	113,487	2,692	173,633	1,737,548	1,563,915	532,565	341,532	874,097	198.78	178.92
1955	750,739	349,317	353,668	35,771	80,442	116,213	2,967	161,758	1,734,662	1,572,904	532,688	340,314	873,002	198.70	180.17
1956	783,629	336,583	368,648	36,577	81,860	118,437	3,690	166,550	1,777,537	1,610,987	533,113	342,678	875,791	202.96	183.95
1957	783,267	342,671	377,094	39,426	84,192	123,618	3,410	139,760	1,769,820	1,630,060	533,144	340,119	873,263	202.67	186.66
1958	778,189	355,872	381,830	45,404	86,618	132,022	2,522	136,938	1,787,373	1,650,435	533,674	349,792	883,466	202.31	186.81
1959	776,050	361,921	380,555	46,128	88,280	134,408	2,903	132,127	1,787,964	1,655,837	528,762	348,978	877,740	203.70	188.65
1960	766,409	372,892	381,758	50,548	91,598	142,146	3,118	121,544	1,787,867	1,666,323	525,580	343,643	869,223	205.69	191.70
1961	782,510	372,550	378,730	52,021	90,554	142,575	2,964	115,546	1,794,875	1,679,329	528,149	343,610	871,759	205,89	192.64
1962	794,228	364,174	369,068	55,954	94,248	150,202	2,520	114,158	1,794,350	1,680,192	530,354	341,504	871,858	205.81	192.71
1963	749,220	349,947	381,662	65,954	101,685	167,639	2,520	102,346	1,753,334	1,650,988	528,709	343,499	872,208	201.02	189.29
1964	764,935	365,348	405,692	82,513	101,107	183,620	2,375	91,234	1,813,204	1,721,970	531,790	350,449	882,239	205.52	195.18
1965	772,918	352,779	395,587	94,010	108,808	202,818	2,340	79,528	1,805,970	1,726,442	536,772	352,791	889,563	203.02	198.12
1966	788,635	364,187	361,659	107,215	112,886	220,101	2,492	76,896	1,813,970	1,737,074	537,399	358,948	896,347	202.37	193.79
1967	787,097	363,506	369,017	113,541	114,754	228,295	426	74,247	1,822,588	1,748,341	537,575	364,832	902,407	201.97	193.74

Source: PDAF Taiwan Agricultural Yearbook and TSC Sugar Statistics

1) Not including mildew acreage.

b) For 1967 by city and county

County/City	Planted acreage (ha)										Cultivated land (ha)			Multiple cropping index	
				Horticultural crops[1]					Total						
	Rice	Common crops	Special crops	Fruits	Vegetables	Total	Other crops	Green manure crops	Incl. green manure crops	Not incl. green manure crops	Paddy field	Dryland	Total	Incl. green manure crops	Not incl. green manure crops
Taipei City	7,716	329	35	750	1,441	2,191	—	—	10,271	10,271	4,237	3,064	7,301	140.68	140.68
Keelung City	785	410	96	206	113	319	—	—	1,610	1,610	532	373	905	177.90	177.90
Taipei County	36,140	7,910	13,773	6,834	8,516	15,350	13	2.938	76,124	73,186	24.215	24,988	49,203	154.71	148.74
Ilan County	41,552	5,357	2,777	2,332	3,281	5,613	10	269	55,578	55,309	21,142	6,944	28,086	197.89	196.93
Taoyuan County	82,362	7,163	7,983	1,402	7,282	8,684	—	7,212	113,402	106,192	45,396	11,289	56,685	200.06	187.34
Hsinchu County	36,258	9,470	13,916	6,651	5,302	11,953	102	5,419	77,118	71,699	21,126	22,093	43,219	178.44	165.90
Miaoli County	37,364	13,462	15,333	4,965	6,096	11,061	72	8,474	85,766	77,292	22,543	19,972	42,515	201.73	181.80
Taichung City	12,396	4,472	3,275	866	1,572	2,438	—	29	22,610	22,581	6,702	2,214	8,916	253.59	253.26
Taichung County	57,195	17,987	14,021	9,447	10,770	20,217	4	2,537	112,961	110,424	33.904	13,475	47,379	238.42	233.07
Changhua County	107,522	32,493	20,829	7,215	15,324	22,539	6	3,860	187,649	183,389	56,294	20,923	77,217	243.02	237.50
Nantou County	27,363	13,936	16,313	19,853	3,875	23,728	1	2,032	83,373	81,341	17,924	33,766	51,690	161.29	157.36
Yunlin County	70,027	34,799	62,609	1,760	8,371	10,131	—	4,344	181,910	177,566	66,211	20,776	86,987	209.12	204.13
Chiayi County	46,738	34,436	36,611	7,385	8,249	15,634	—	8,108	141,527	133,419	52,197	19,381	71,578	197.72	186.40
Tainan County	51,768	54,043	55,264	8,647	8,844	17,491	1	8,032	186,599	178,567	63,846	34,858	98,704	189.05	180.91
Tainan City	3,723	4,362	2,671	43	1,651	1,694	—	320	12,770	12,450	3,886	2,251	6,137	208.08	202.87
Kaohsiung City	6,590	2,520	1,400	79	902	981	—	241	11,732	11,491	3,227	1,373	4,600	255.04	249.80
Kaohsiung County	40.368	26,739	28,653	11,702	7,938	19,640	1	4,168	119,569	115,401	31,453	26,610	58,063	205.93	198.75
Pingtung County	76,466	52,338	30,191	13,460	8,016	21,476	16	7,411	187,898	180,487	40,163	40,855	81,018	231.92	222.77
Taitung County	19,143	17,502	19,048	6,944	3,398	10,342	105	3,298	69,438	66,140	11,051	28,775	39,826	174.35	166.07
Hualien County	22,062	18,185	20,217	2,992	3,360	6,352	94	5,555	72,469	66,910	11,527	23,867	35,394	204.75	189.04
Penghu County	—	5,593	3,002	8	453	461	—	—	9,056	9,056	—	6,985	6,985	129.65	129.65
Grand total	787,097	363,506	369,017	113,541	114,754	228,295	426	74,247	1,822,588	1,748,341	537,575	364,832	902,407	201.97	193.74

Source: PDAF Taiwan Agricultural Yearbook, 1968; and TSC Sugar Statistics, 19th issue.

c) For 1967 by season and area

Area	Cultivated land (ha)	Planted acreage (ha)						Multiple cropping index						Fallow and waste land (ha)		
		Not including green manure crops			Including green manure crops			Not including green manure crops			Including green manure crops					
		Winter crop	1st crop	2nd crop	Winter crop	1st crop	2nd crop	Winter crop	1st crop	2nd crop	Winter crop	1st crop	2nd crop	Winter	Spring	Fall
Taipei	85,494	32,851	82,501	78,725	35,693	82,536	79,055	38.42	96.50	92.08	41.75	96.54	92.47	49,801	2,908	6,439
Hsinchu	142,419	72,925	137,142	130,849	94,023	137,142	130,856	51.20	96.29	91.88	66.02	96.29	91.88	48,396	5,277	11,563
Taichung	185,202	146,257	195,371	195,205	153,511	196,281	195,499	78.97	105.49	105.40	82.89	105.98	105.56	31,691		
Tainan	263,406	206,188	263,043	263,949	210,335	276,764	266,885	78.28	99.86	100.21	79.85	105.07	101.32	53,071		
Kaohsiung*	143,681	140,615	146,048	160,256	142,700	151,006	164,833	97.87	101.65	111.54	99.32	105.10	114.72	981		
Taitung	39,826	26,094	41,821	40,612	27,435	42,271	42,119	65.52	105.01	101.97	68.89	106.14	105.76	12,391		
Hwalien	35,394	19,242	38,205	35,295	24,592	38,280	35,425	54.37	107.94	99.72	69.48	108.15	100.09	10,802		
Penghu	6,985	429	2,573	6,070	429	2,573	6.070	6.14	36.84	86.90	6.14	36.84	86.90	6,556	4,412	915
Total	902,407	644,601	906,704	910,961	688,718	927,053	920,742	71.43	100.48	94.81	76.32	102.73	102.03	213,689	12,597	18,917

* Not including Penghu.

Table 6. Planted Acreage of Main Winter Crops

Unit: ha

Crop	1963 (1962/63)	1964 (1963/64)	1965 (1964/65)	1966 (1965/66)	1967 (1966/67)	1968 (1967/68)	1969 (1968/69)	Local wholesale prices (NT$/kg)				
								1965	1966	1967	1968	1969
Sweet potato												
Fall planted	121,413	132,414	122,614	120,624	119,100	119,365	117,977	0.78	0.60	0.79	0.86	
Hu-tzu planted	44,805	48,279	43,128	43,856	44,922	46,082	41,543	0.78	0.70	0.82	0.94	0.76
Wheat	14,375	9,397	11,119	14,356	11,891	7,713	4,660	4.07	4.07	4.22	3.81	
Corn	7,301	8,509	5,714	7,811	9,282	7,624	7,004	3.97	4.01	3.58	3.42	3.09
Soybean	31,266	31,255	37,081	37,034	38,157	37,387	34,633	6.02	6.44	6.51	5.70	5.76
Multiflora bean		3,581	2,338	2,630	2,623	3,184	3,546	5.04	4.87	5.12		
Other beans	7,831	9,846	6,765	6,935	5,704	6,330	7,607					
Rapeseed	10,398	19,598	17,593	7,679	4,498	2,888	2,243	5.34	5.47	6.65	5.63	6.00
Flax	3,986	4,517	5,524	4,168	3,964	4,489	3,236	0.80	0.85	0.95	0.95	0.95
Other food crops	481	834	1,191	1,201	936	707	1,118					
Tobacco	8,370	8,364	7,795	7,400	9,831	10,863	11,586	20.70	20.90	20.90	21.10	21.60
Vegetables	50,500	49,751	47,622	46,411	53,377	55,810	60,173	0.66	0.95	0.81	0.61	0.81
Green manure crops	55,606	53,370	48,139	45,605	44,117	42,206	38,411					
Total (excl. green manure)	300,726	326,345	308,484	300,105	304,285	302,442	295,326					
Total (incl. green manure)	356,332	379,715	356,623	345,710	348,402	344,648	333,737					

THE FARM MECHANIZATION PROGRAM AND ITS PROBLEMS

Tien-Song Peng

The farm mechanization program initiated by JCRR more than 10 years ago has been making good progress, especially in the past few years. Two big farm machinery companies have been established to produce power tillers and other farm machinery/implements, which are being used more and more by the farmers. The fact that farmers are now aware of the advantages of machines is reflected in the rapidly decreasing number of draft animals.

Important Events in the Process of Developing the Farm Mechanization Program in Taiwan

1947: Tractor farming was first used in sugarcane fields by the Agricultural Machinery Operation and Management Office of the Board of Trustees for Rehabilitation Affairs (AMOMO, BOTRA).

1950: AMOMO was merged into the Taiwan Sugar Corporation (TSC) with 200 small tractors.

1951: The number of tractors in TSC was increased to 350.

1954: JCRR imported 7 garden tractors from the United States.

1955: The first batch of 2 power tillers was imported by JCRR from Japan.

1956: JCRR again imported 13 power tillers from Japan; meantime TSC had 489 tractors.

1959: As many as 22 small manufacturers began to produce power tillers, and meantime 16 brands of power tillers were imported.

1960: Nineteen out of 22 farm machinery manufacturers either became bankrupt or stopped producing power tillers.

1961: Two big agricultural machinery companies, AGRIMA and TAIWAN AGRI, set up factories.

1963: Mist-blowers or dusters were introduced from West Germany.

1966: The first township farm mechanization promotion center was established at Talin, Chiayi. The farmers in northern Taiwan adopted the grain dryers under JCRR support.

1967: Test on the aerial application of pesticides was initiated in Taiwan.

1968: A modified form of hand-push type rice transplanter was demonstrated to farmers.

The Role Played by JCRR in Implementing the Farm Mechanization Program

A. Start of the program

The era of farm mechanization in

Taiwan was ushered in when JCRR took the initiative in importing seven garden tractors of 1.5 to 10 h.p. from the United States in 1954 and two power tillers from Japan in 1955.

B. Promotion of farm mechanization

1) Training of farmers and agricultural extension workers: To provide basic-level agricultural workers and farmers with more knowledge about farm machinery, especially power tillers, JCRR assisted government agricultural agencies and FAs in conducting various training classes in the past. In the first five years, altogether 833 persons, including extension workers from local governments and FAs, attended the training classes. In the meantime, 781 farmers were trained in the techniques of operating, maintaining and repairing farm machinery. In 1961, the training program was taken over by PDAF and local farm machinery manufacturers. Up to 1968, a total of 14,182 farmers were trained by government agencies.

2) Demonstrations, field days and operation contests: Farm machinery demonstrations, field days and power tiller operation contests were often held by the agencies concerned with JCRR support for arousing the farmers' interest in mechanized farming. The responsibility for conducting power tiller demonstrations and operation contests was later shifted to the Provincial Food Bureau.

3) Subsidies to farmers for purchasing farm machines: To promote the use of new farm machinery, JCRR made subsidies to farmers to help them buy sprayers, mist-blowers, sprinkler sets, grain dryers, etc.

4) Establishment of township farm mechanization promotion centers: Since 1966, JCRR has rendered necessary assistance to PDAF, local governments and FAs for establishing township farm mechanization promotion centers in selected townships. It is expected that through the centers the utilization of the existing farm machines can be intensified. The main functions of the center are:

a. Maintenance and repair of farm machines owned by individual farmers.

b. Promotion of full utilization of farm machines, especially power tillers, owned by individual farmers, through custom work whenever possible.

c. Helping of farmers desiring to buy farm machines in completing the bank loan procedures.

d. Research institutions are assisted in field-testing and demonstration of newly developed farm machines.

e. Farmers training program has been carried out in respective townships.

C. Quality of farm machinery assured

1) Power tiller test: To make sure that the power tillers bought by farmers are of good quality and give excellent performance, the government, at JCRR suggestion, has established a rule to the effect that any new model of power tillers should be thoroughly inspected before it is put on the market. JCRR has also strengthened the testing facilities of the College of Agriculture, NTU for conducting the inspection work.

2) Mist-blower test: JCRR supports NTU in the inspection of mist-blower which is now getting popular in rural areas.

3) Fuel and oil supply: To enable farmers to get fuel and oil of good quality for their farm machines, JCRR assisted the China Petroleum Corporation to establish 25 gas stations at suitable locations.

4) Training of technicians in the care and repair of machines: Farm machines must be kept in good condition all the time, especially during the farming season. This will not only assure the performance of the machine but also strengthen the confidence of farmers in the machine. To train the maintenance workers required, JCRR has assisted PDAF in conducting classes for about 145 persons so far.

D. *Introduction, modification and development of farm machines*

1) JCRR has assisted PDAF in training research personnel by arranging with NTU to hold special classes lasting from a month to a year.

2) Through JCRR assistance, several agricultural research stations have built workshops equipped with power tools for the development of new farm machines. The workshops are located in NTU, TARI, Hsinchu, Taichung, Tainan and Taitung DAISs, Tainan FCES and Taiwan TES.

3) Many kinds of farm machinery, such as power tiller and tractor, sprayer, mist-blower, sprinkler set, decorticator, grain dryer, corn sheller, seed cleaner, rice reaper, peanut thresher, rice transplanter, etc., were imported from abroad with JCRR assistance.

4) The farm mechanization program has been sped up through research and development of farm machinery/implements or modification and improvement of the introduced ones to suit the small-farm agriculture of Taiwan. Dozens of such machines have been developed or modified and proved to be useful, such as corn sheller, peanut thresher and sheller, jute decorticator, grain dryer, sweet potato harvester, tea cutter, soybean planter, sorghum thresher, peanut planter, rice transplanter, etc.

Future Problems

Agriculture in Taiwan has advanced to such an extent that farm mechanization is bound to gain in popularity in the years to come, because it can replace not only animal labor but also part of the human labor being absorbed by the booming industry. However, there are still many problems to be solved in the future.

1) Problems concerning marketing of farm machinery:

a. Relatively high cost of machinery/implements.

b. Small-scale farming and fragmentation of land.

c. Diversified and intensive cropping systems.

d. Low income and hence low purchasing power of average farmers.

e. Farm population still not quite psychologically prepared to accept mechanization.

f. Lack of sufficient maintenance service for the machines.

2) Problems concerning supply of farm machinery:

a. High interest of bank loans and limited production of farm machinery.

b. Lack of standardization of machine

parts and attachments produced by local manufacturers.

c. Complicated after-service system.

d. Insufficient number of qualified engineers to conduct research on farm machinery.

e. Lack of modern manufacturing techniques and limited capitalization on the part of small manufacturers.

Suggested Ways to Further Develop Farm Mechanization in Taiwan.

1) To speed up the project on the establishment of more township farm mechanization promotion centers.

2) To strengthen the training of research workers.

3) To lower the interest rates on loans and prices of farm machinery.

4) To include mechanized farming in the land consolidation program.

5) To insure the quality of farm machinery by strengthening the inspection system.

6) To hasten the development of such farm machinery/implements that suit the local farm conditions.

7) To extend engineering techniques to the fields of food processing and post-harvest handling.

THE CHANGING RICE DISEASE SPECTRUM OF TAIWAN

Ren-Jong Chiu

In the last fifteen years, there have been some new developments in rice culture which greatly affect the rice disease spectrum of Taiwan. Fertilizer use in the rice field tends to be increasingly heavier while dense planting is becoming a general practice. There has also been an apparent shift toward a late planting time in the first crop season and early in the second. This is usually desirable because of the operation of a multiple cropping system. Perhaps, the more fundamental change in the disease situation has been due to varietal change in the last 15 years, during which a total of 32 new rice varieties were released and some of them are gaining acreage rapidly. For example, Taichung Native No. 1, a blast resistant variety first released in 1956, was grown in a total area of 78,663 ha in the peak year of 1965, but after that there has been a decline in its acreage because of the release of another *indica* variety Taichung Sen No. 2. On the contrary, the planted area of Taichung 65, a *japonica* variety susceptible to blast, has decreased from 110,955 ha in 1956 to 22,081 ha in 1968. The quick acceptance of the new variety Tainan No. 5, a *japonica* variety released in 1965 and extended to 199,369 ha in three years, is expected to produce a profound effect on the rice disease situation, which has not been apparent yet.

The following is a brief account of the rice disease situation as it exists under the effect of the above mentioned factors.

Blast

Although blast remains to be an important disease of threatening nature, its actual outbreak has been rare in recent years and usually not to the extent as to devastate rice production in wide areas. This has been due partly to the gradual replacement of susceptible varieties, notably Taichung 65, with those possessing moderate to strong resistance, and partly to the extensive use of organomercuric compounds as field fungicides for combating the disease.

The appearance of new physiological races of the blast fungus might have complicated the rice breeding program. However, with resistance sources amply available as through international exchange programs, there should not be a lack of desirable resistance genes for breeding purposes. In the past, there were cases in which rice varieties showed contrast reactions with locations. Gradual breakdown of blast resistance has not been noted in any resistant varieties in Taiwan, however.

Sheath Blight

Sheath blight occurs widely in Taiwan but drew little attention before the middle of 1950's. Since then it has become a major disease for the second crop throughout the island and caused substantial damage to the first crop in Pingtung and other parts in southern Taiwan. Although sheath blight seldom causes a complete crop failure, the annual toll it takes from the rice production must be phenomenal in view of its extensive occurrence.

Since the disease is favored by high temperature, its increasing seriousness in recent years can partly be ascribed to the shift toward late planting in the first crop and early planting in the second as demanded by the multiple cropping systems. Another new cultural practice, that of closer spacing, also tends to aid in the disease spread.

Chemical control of sheath blight is possible with several organic arsenic compounds applied to the sheaths and lower leaves. In practice, however, proper coverage is often difficult to achieve, especially at the stages of active tillering and immediately before heading when control is most needed. Sheath blight will very likely continue to be a major disease problem in the near future, for neither more effective means of chemical control nor the successful development of resistant varieties can now be foreseen.

Bacterial Leaf Blight

Bacterial leaf blight is mainly a disease problem for *indica* rice in Taiwan. Most varieties of the *japonica* type show some degree of resistance and are generally not as badly affected as *indica* rice. Two highly susceptible varieties of *indica* rice, namely, Taichung Native 1 released in 1956 and Taichung *sen* No. 2 released in 1966, have been grown extensively, since 1966 with a combined acreage of about 100,000 ha or over half of the total *indica* rice area. Serious outbreaks of bacterial leaf blight have frequently occurred in the second crop in the Taichung and Pingtung areas.

Yellow Dwarf

Yellow dwarf was first known to occur in Taiwan in the 1930's with its distribution limited to a few rice growing areas in the north, e.g., Ilan, Taipei and Hsinchu. The disease caused by a *Mycoplasma* and transmitted by green leafhoppers has since spread gradually southward. By 1960, it had become a serious problem in the second rice crop in Taitung and several areas north of Taichung. By 1968, it had spread further southward with a total disease acreage of 25,852 ha. Thus far the disease has not been found in Pingtung and Kaohsiung. Whether these two major rice growing areas will, by climatic or other reasons, remain free from yellow dwarf infection in the future is not certain.

The emergence of yellow dwarf as a major disease in Taiwan in recent years raises the question about the effectiveness of leafhopper control much emphasized as a measure against the disease in the existing rice pest control program. It also remains to be determined whether the new varieties now under cultivation widely are more susceptible than some old varieties to the disease or its vector leafhoppers, thus providing a favorable condition for the disease spread.

Transitory Yellowing

Transitory yellowing is a new virus disease of rice transmitted by two green leafhoppers, *Nephotettis apicalis* and *N. cincticeps*. It occurred in the Pingtung area to an epidemic extent during 1960-1962 and was misidentified as a type of physiological disorder resulting from a reduced soil condition. Experimental evidence showing that the disease is not associated with an undesirable soil condition but is of virus origin was obtained in late 1962 when transmission of the disease was effected in an experiment using leafhoppers as vectors.

A survey made in 1963 set the area affected by the desease at 3,870 ha, which has fluctuated ouly slightly in subsequent years. To date, the disease is widely distributed in the rice areas of Pingtung, Yunlin, Nantou, Changhwa, Taichung and Taitung. It can also be occasionally found in the Taipei area.

During 1960-1962 when the disease was most serious, several *japonica* varieties developed by the Kaohsiung DAIS and extensively grown in the disease areas were highly susceptible. Gradual replacement of these varieties, e.g., Kaohsiung 10, Kaohsiung 22 and Kaohsiung 68, with the less susceptible, together with a vigorous program for the control of the vector leafhoppers appears to have resulted in a decline in severity of the disease, though the extensiveness of its spread has remained largely unchanged.

White Tip

Nematode white-tip of rice due to the nematode *Aphelenchoides besseyi* seems to have become a problem of increasing economic importance in recent years in Taiwan. Control of the disease can be effective by treating rice seed with heat, methyl bromide and a number of organic phosphorus insecticides. However, this has not been practised to any significant extent. Neither has any official recommendation for controlling the disease ever been made. It is not uncommon to find that fields intended for producing original seed are heavily infested which adds to the possibility of disease spread.

Helminthosporium Leaf Spot

The leaf spot of rice caused by *Helminthosporium oryzae* is not considered an important disease problem because of the present trend toward heavy use of fertilizers, which is generally believed to disfavor the occurrence of the disease. Field application of organic mercuric fungicides for blast control also suppresses Helminthosporium leaf spot effectively. However, in some areas in the eastern regions where the use of fertilizers is inadequate, this disease frequently occurs and causes some losses.

Seedling blight and Bakanae disease of rice caused by *Gibberella fujikuroi* can be considered an example in which a previous major disease problem has been rendered rather unimportant by the effective use of fungicides. The disease agent does not survive long in the field soil and is normally carried over to the next crop season by the rice seed. Treatment of seed with mercuric fungicides has proved highly effective against seedling blight. There, however, have been some recent complaints by rice growers about the ineffectiveness of seed treatment. This will need future clarification.

A fact that probably warrants serious attention of rice protection workers is that a virus disease either identical or closely related to stripe has been found in the Taichung area. Transmission of this disease by the small brown planthopper *Leodelphax striatellus* has been experimentally obtained at the Taiwan Provincial Chung Hsing University. Without knowing the distribution of this disease it is too early to speculate its possible impact on rice production in Taiwan in the future.

PRESENT STATUS OF PLANT PROTECTION RESEARCH IN TAIWAN

Ren-Jong Chiu

Recently, this Division conducted a survey of the present condition of plant protection research in Taiwan, with manpower availability and financing situation as its focal points. The following institutions were covered by this survey. Information obtained has been analyzed and tabulated as shown in the following pages.

1) National Taiwan University (NTU)

   Department of Plant Pathology and Entomology

2) Taiwan Provincial Chung Hsing University (PCHU)

   a. Department of Plant Pathology

   b. Department of Entomology

3) Academia Sinica

   Institute of Botany

4) Taiwan Agricultural Research Institute (TARI) and its four branch stations:

   a. Shihlin Horticultural Experiment Station

   b. Chiayi Agricultural Experiment Station

   c. Tainan Fiber Crops Experiment Station

   d. Fengshan Tropical Horticultural Experiment Station

5) Taiwan Tea Experiment Station

6) Six District Agricultural Improvement Stations

7) Taiwan Sugar Experiment Station

8) Taiwan Tobacco Research Institute

Since some of the institutions, the Kaohsiung DAIS for example, did not respond to the survey and others (Tainan DAIS) failed to provide monetary data on the industry-supported research, the information is not considered complete. Despite this, some features, e.g., a shortage of highly trained research workers and a large proportion of research funds allocated to those with B.S. degrees, derived from an analysis of the data would not be affected by the omissions.

Manpower Status of Plant Protection Research in Various Agricultural Institutions in Taiwan (1968)

	Total	TARI	TARI's Br. Sta.	DAISs	NTU	PCHU	Academia Sinica	TSES	TTRI
Permanent position holder									
With Ph.D.	9	1	0	0	4	2	1	1	0
With M.S.	13	2	2	0	2	2	1	3	1
With B.S.	56	6	7	13	5	12	0	7	6
Below B.S.	50	12	6	20	1	0	0	8	3
Sub-total	128	21	15	33	12	16	2	19	10
Temporary position holder									
With M.S.	3	2	0	0	1	0	0	0	0
With B.S.	40	7	5	3	10	9	5	1	0
Below B.S.	14	3	7	4	0	0	0	0	0
Sub-total	57	12	12	7	11	9	5	1	0
Total	185	33	27	40	23	25	7	20	10

Distribution of Funds Among Agricultural Institution for Plant Protection Research in Taiwan (1967)

Unit: NT$

Institution	JCRR contribution	Government source	Industry contribution	USDA assistance	Total
TARI	590,890	739,875	1,105,000	222,040	2,657,805
TARI's Br. Stations	676,800	80,560	294,340	—	1,051,700
DAISs	853,880	173,000	272,000	—	1,298,880
NTU	918,960	20,000	281,800	—	1,220,760
PCHU	770,770	—	254,500	—	1,025,270
Academia Sinica	130,000	—	—	—	130,000
TSES	—	—	873,984	—	873,984
TTRI	—	—	146,908	—	146,908
Total	3,941,300	1,013,435	3,228,532	222,040	8,405,307
%	46.89	12.06	38.41	2.64	100.00

Distribution of Research Funds in Various Agricultural Institutions in Taiwan as Viewed from the Basis of Educational Training of the Researchers (1967)

Educational training	Provincial agricultural institutions		Universities and academic institutions		Industry-supported institutes		Grand total			
	NT$	%	NT$	%	NT$	%	NT$	%	No. of researchers	No. of projects
With Ph.D.	20,000	0.40	756,900	31.86	198,766	19.47	975,666	11.61	7	15
M.S.	308,770	6.17	823,780	34.67	529,201	51.84	1,661,751	19.77	12	27
B.S.	2,209,260	44.11	795,350	33.47	272,225	26.66	3,276,835	38.98	41	73
Below B.S.	2,470,355	49.32	—	—	20,700	2.03	2,491,055	29.64	30	62
Total	5,008,385	100.00	2,376,030	100.00	1,020,892	100.00	8,405,307	100.00	90	177
%	65.86		25.76		8.38		100			

Distribution of Research Funds Among Research Personnel
Holding Different Academic Degrees (1967)

	Agency	Educational training	NT$	%	No. of researchers	No. of projects
Provincial agricultural institutions	TARI	With Ph.D.	20,000	0.75	1	1
		M.S.	70,000	2.64	3	5
		B.S.	1,126,740	42.39	3	8
		Below B.S.	1,441,065	54.22	8	21
		Sub-total	2,657,805	100.00	15	35
	TARI's Br. Sta.	With Ph.D.	—	—	—	—
		M.S.	238,770	22.70	2	6
		B.S.	604,100	57.44	8	16
		Below B.S.	208,830	19.86	5	9
		Sub-total	1,051,700	100.00	15	31
	DAISs	With Ph.D.	—	—	—	—
		M.S.	—	—	—	—
		B.S.	478,420	36.83	12	23
		Below B.S.	820,460	63.17	16	31
		Sub-total	1,298,880	100.00	28	54
Universities and academic institutions	NTU	With Ph.D.	616,900	50.53	3	9
		M.S.	251,010	20.56	1	5
		B.S.	352,850	28.91	3	6
		Below B.S.	—	—	—	—
		Sub-total	1,220,760	100.00	7	20
	PCHU	With Ph.D.	50,000	4.88	1	1
		M.S.	572,770	55.86	2	5
		B.S.	402,500	39.26	3	7
		Below B.S.	—	—	—	—
		Sub-total	1,025,270	100.00	6	13
	Academia Sinica	With Ph.D.	90,000	69.23	1	2
		M.S.	—	—	—	—
		B.S.	40,000	30.77	1	1
		Below B.S.	—	—	—	—
		Sub-total	130,000	100.00	2	3
Industry-supported institutes	TSES	With Ph.D.	198,766	22.74	1	2
		M.S.	509,873	58.34	3	5
		B.S.	144,645	16.55	4	4
		Below B.S.	20,700	2.37	1	1
		Sub-total	873,984	100.00	9	12
	TTRI	With Ph.D.	—	—	—	—
		M.S.	19,328	13.16	1	1
		B.S.	127,580	86.84	7	8
		Below B.S.	—	—	—	—
		Sub-total	146,908	100.00	8	9
Total		With Ph.D.	975,666	11.61	7	15
		M.S.	1,661,751	19.77	12	27
		B.S.	3,276,835	38.98	41	73
		Below B.S.	2,491,055	29.64	30	62
		Grand total	8,405,307	100.00	90	177

PLANT PROTECTION IN TAIWAN

Tsong-Tseat Lo

Introduction

Plant protecton is a branch of applied science involving the control of plant diseases, harmful insects and animals and weeds. It plays an important role in agricultural improvement same as a medical doctor in the human society.

The nature of plant protection is, however, different from other agricultural sciences. It is not so simple as distributing improved seeds and fertilizers, but it needs special knowledge in practice. The following are some common examples:

1) Plant protection deals mostly with microscopic things which are invisible to the naked eye, such as disease pathogens and the eggs of insect pests. However, the behavior of these tiny things is not popularly known.

2) Due to environmental factors, most of the disease pathogens can produce new physiological races whose pathogenisity is different from that of their parents. This hereditary change is known as variation and mutation. New races can reattack the plant varieties which are originally resistant to the disease.

3) Almost all the insect pests can be controlled by the application of pesticides. Yet a certain pesticide may be very effective at first, but becomes useless sometime later because some insects can produce new progeny with a special enzyme system to detoxicate the chemical. This phenomenon is known as insecticide-resistant insect species. Once a resistant species is found, the only effective control method is to apply heavier dosage of the same chemical or shift to another kind of insecticide.

4) Many pesticides and herbicides are powerful enough to kill the pathogens, insects and weeds, but they are also toxic to humans. The properties of the chemicals are too complicated to be understood by the farmers, so a knowledge of their proper use is necessary.

5) In pest control, "prevention" is more important than "remedy". It is often the case that when prevention work has been done, the seriousness of the pest problem may become temporarily less severe, but the importance of the problem is apt to be overlooked.

Measures of Plant Protection

There are many ways to carry out plant protection measures, each with its own advantages and disadvantages. The following are examples illustrating some major measures of disease and insect pest control.

A. Exclusion of disease pathogen and insect pest

Quarantine prevents exotic pathogens and insects from entering a country while eradication of diseased plants eliminates the pathogens already in the field; both methods are effective in checking the spread of pests if execution is strict enough. However, it is very costly to maintain the necessary facilities for quarantine and to destroy large numbers of diseased and possibly diseased plants for the promotion of the eradication program.

B. Use of resistant host varieties

Many seccessful cases have been reported in the control of certain diseases by making use of resistant crop varieties. This is a most feasible method for farmers and it is often used by the plant pathologists. Crop varieties resistant to insect pests have been investigated but successful cases are rather rare.

The disadvantage of this method is that the pathogen may produce new races which can break the host resistance.

C. Application of pesticides

Quick effect of pest control can be obtained through pesticide application, for there will be no problem of races involved. However, it gives rise to such problems as toxic residues, plant injury and expenses of application for each cropping, etc.

Research and Extension

Without extension, all the new research findings will never reach the farmers for application in the field while extension without being strengthened by research will fail to improve the techniques of plant protection. In the past decade, the work of both research and extension in plant protection has been carried out in a well coordinated manner and fruitful results have been obtained.

In Taiwan, when a new project of plant protection is initiated by the government, subsidy either in kind or in cash is always available to the contract farmers who demonstrate the proven methods in the field. We consider a project successful if farmers are willing to adopt the methods after witnessing the good results, otherwise it is a failure.

The following chart shows the research and extension on the control of major diseases and insect pests in Taiwan.

Progress of Pest and Disease Control in Taiwan

Crop	Disease & insect pest	Research	Extension
Rice	Blast	————————	————————
	Bakanae disease	————————	————————
	Sheath blight	————————	————————
	Culm rot	—	
	Transitory yellowing	————————	—
	Yellow dwarf	————————	—
	Bacterial leaf blight	—	
	Borers	————————	————————
	Plant hoppers	————————	————————
	Leaf hoppers	————————	——

Crop	Disease & insect pest	Research	Extension
Sweet potato	Witches' broom		
	Soil pests		
	Weevil & vine borer		
Wheat	Rust		
Corn	Downy mildew		
	Borer		
Soybean	Rust		
	Insect pest		
Sugarcane	Downy mildew		
	White leaf disease		
	Stunting disease		
	Borers		
	Woolly aphids		
Tobacco	Bacterial wilt		
	Mosaic (TMV)		
	Mosaic (CMV)		
	Leaf roll		
	Tobacco beetle		
Fiber crops	Nematodes of jute		
Peanut	Corticum wilt		
Pineapple	Mealybug wilt		
	Marbled disease		
	Pink disease		
Banana	Bunchy top		
	Cercospora leaf spot		
	Weevil		
Citrus	Tristeza		
	Black spot		
	Powdery mildew		
	Insect pests		
Vegetables	Virus disease		
	Diamond back moth		
	Mushroom flies		
	Asparagus stem rot		

Proposed Activities of Plant Protection in Near Future

A number of diseases and insect pests have been limiting the production of crops in Taiwan. Research should be strengthened in order to find effective control methods. Efforts should also be made to improve existing control methods for better results.

Plant protection technicians at various levels of government and farmers' associations play an active role in plant protection extension. They disseminate the scientific knowledge developed by researchers to farmers and bring back field problems to the research workers. In order to maintain the efficiency of the overall program of plant protection, technicians should receive on-the-job training periodically so as to keep their knowledge up-to-date.

The small-farm agriculture of Taiwan puts the island in a situation similar to that in many other Asian countries, i.e., large number of farmers vs. small size of land holdings. Since it is difficult to teach farmers modern knowledge individually, cooperative pest control becomes necessary. In 1960, cooperative pest control teams for rice were first organized, each covering 100 hectares of paddy field, with operations under the strict supervision of the government. It was found that cooperative control could result but only in higher rice yield, and also in lower cost because pesticides of standard quality could be purchased at a bargain by group action.

In view of the success achieved with rice, cooperative control teams for citrus and vegetables have also been established and the advantages of this practice have been generally recognized. It is proposed that the government should make further efforts to strengthen the system for more fruitful results in plant protection.

PLANT PROTECTION IN MOUNTAIN AREAS

David F. Yen

The plant protection work in the mountain areas was initiated by MARDB with JCRR assistance in 1962. In the past years, emphasis has been placed on "on-the-spot" and "large-scale" demonstrations of control techniques successfully used in the lowland areas with pesticides provided by JCRR. Some of the major activities done and the results obtained are summarized as follows:

1) Control of soil insects: Demonstrations on control practices were made on 148 ha of dryland crops in 1963 and 1964. The resultant data showed a 12-22% increase in net income for sweet potato farmers and 60% increase for potato growers in the demonstration fields.

2) Control of major rice diseases and insect pests: In 1964, a total of 20 ha of demonstration plots were set up in a number of rice fields, in which an average increase of 18% in net income over the check plots was obtained. The average increase obtained from the 60 ha of demonstration plots in 1965 was 27-34%, and another 60 ha were demonstrated in 1967 with good results.

3) Control of diseases and insect pests of deciduous fruits: With the assistance of JCRR, the deciduous fruit pests control program was initiated by MARDB in 1966. The program proved very successful, resulting in high percentage of control, and hence higher yields in the demonstration orchards than the untreated ones. The increase in yields amounted to 41-84%, 63-88% and 45-77% for the Japanese pear, Hengshan pear and peach, respectively. The same program carried out in 1967 and 1968 also resulted in excellent control of deciduous fruit pests, especially black spot of Japanese pear and leaf curl of peach.

4) Short-term training classes and demonstrations: In 1966, 75 demonstration plots of 0.1 ha each were set up at 75 localities in 11 prefectures throughout the island. At the same time, short-term training classes were offered by MARDB to teach the young aborigine farmers modern pest control techniques, and a total of 1,328 aborigines attended the classes. Results obtained from the demonstration fields showed an average yield increase of 42.4% for rice; 39.9% for millet; 35.4% for corn; 11.5% for sweet potato; 56.3% for peanut and 55.5% for Hengshan pear. The extension work was continued in 1967 and 1968.

5) Establishment of nine pest control stations: Owing to the successful demonstrations and extensive training programs undertaken by MARDB in the past, most of the farmers in the mountain areas have become aware of the importance of pest control to crop production and are willing to spend their money for the pest control programs. Hence

the time has come for the local county governments to set up permanent pest control stations within their respective areas with the assistance of JCRR and MARDB. If so, the JCRR budgets for the plant protection programs in the mountain areas can be reduced gradually. Four pest control stations were set up in Lishan, Wufeng, Fuhsing and Mutan in 1968, while another five pest control stations are to be established in Shulin, Yenping, Shihtze, Chienshih and Nan-ao in 1969.

Vegetables including cabbage, tomato and pepper are also planted in the mountain areas. For instance, on the Chienching Farm (VACRS), some 50 ha of land are devoted to cabbage raising, but cabbage is susceptible to the attacks of soil insects, such as the june beetle (*Holotrichia* spp.) and the cutworm (*Euxoa segitis*). In 1968, about 80 percent of the crops were completely destroyed by these pests.

The cutworm is a common species which occurs in the plain areas. This insect severs seedlings within one or two days after the plant was transplanted. The june beetle, *Holotrichia* spp., seems to have a special preference for cool weather. The adults are bronze or brown in color nearly one inch long and half as wide, feeding on foliage and leaves of Chinese chestnut, Japanese apricot and alnus trees. In the spring and early summer, the adults would emerge and become active, and fly about during the night. They come out from the soil just at dusk and remain on the trees during the night, mating and feeding. At the first streak of dawn, they return promptly to the soil. In April 1969, a piece of land about one square meter in size, surrounding a Chinese chestnut, was plowed to a depth of three inches and checked: a total of 103 adults were collected. The larvae of the beetle, or the grubs, are the most destructive and troublesome pests of cabbage. The grubs are white with brown heads and three pairs of prominent legs. They feed on the roots or underground parts of cabbage. When a cabbage is pulled up, its roots are most likely gone and from several to a hundred or more white curved-bodied grubs may be found in the soil surrounding the roots. The population density of this pest in the area can be said very high.

The following measures for controlling these pests have been suggested:

1) Spray 40% Aldrin W. P. at a dosage of 25 lb/ha for soil treatment. Applications must be conducted about 3-5 days before transplanting.

2) To spray the Japanese apricot, Chinese chestnut and alnus trees with 50% Carboryl W.P. at the concentration of 1:800-1,000 to control adult beetles.

3) To set up light traps to collect adults in the night.

4) To mobilize housewives and schoolchildren to collect adults by hand in early morning.

5) To treat the compost or manure in the gardens with sevin or DDT, or to fumigate it with Chloropicrin to kill the grubs.

6) To dust the pasture with 5-10% DDT dust.

DISEASE PROBLEMS OF MAJOR HORTICULTURAL CROPS PRODUCED FOR EXPORT

Hong-Ji Su

The export of horticultural crops including banana, pineapple, citrus, mushroom, watermelon and vegetables has earned for the nation large sums of foreign exchange. The quality of these fruits and vegetables must be improved and their yields increased in order to cope with the growing domestic demands and sharp competition on the foreign markets. As a result of the intensive cultivation of these crops for export, a number of important diseases have become prevalent, causing considerable damage to their production. The infestation of some market diseases have also greatly affected the export trade of agricultural products. For instance, the epidemic of banana crown rot causes the rotting of banana fruits during their shipments to Japan. The annual loss due to this disease averages as much as NT$40,000,000. We have encountered disease problems in exporting agricultural products in the past. It is quite possible that new diseases may arise in the future. Briefly described below are major destructive diseases affecting banana, citrus and other tropic fruits, their present situation and the ways we have been trying to deal with them.

Major Diseases of Banana

A. *Black leaf streak or Sigatoka disease*

This disease has been limiting the yield and quality of bananas, especially those raised in autumn and winter. Almost 80% of the banana groves in Taiwan are affected by it. The disease was formerly assumed to be the so-called "Sigatoka disease". However, it has recently been identified as "black leaf streak" in most cases according to a comparative study on pathogenic fungus derived from the Honduras banana leaf diseased with the Sigatoka disease. Thus, the disease is mainly attributed to the pathogenic fungus, *Mycosphaerella fijiensis* which was found to be more virulent and resistant to spray oil, besides producing more air-borne ascospores than the Sigatoka fungus.

That the disease can be controlled with fungicide (Dithane M 22 or M 45) plus spray oil has been confirmed by field trials of fungicides in Taiwan. The banana growers have gradually adopted this control practice. In order to improve the effectiveness of control through uniform coverage of the fungicide plus oil on the upper leaves, aerial spray by helicopter has been conducted on a trial basis. The banana growers are now aware of the fact that economical and effective control of the disease can be achieved by aerial spray in the critical period, and that banana trees once sprayed aerially will bear fruits of uniform quality for the entire acreage.

The uniformity of banana quality is required for the grading of bananas prior to shipment. However, because of the wide distribution of banana groves in Taiwan, the scope of aerial application is limited. Nevertheless, as the shortage of agricultural labor will become more acute due to rapid industrialization, mechanization of pesticide application by means of helicopter is necessary for the black-leaf-streak control. The following are suggestions for solving the problem of how to improve the control measure and promote the banana aerial application:

1) Establishment of a disease forecasting system according to the epidemiological data.

2) Standardization of pesticide dosage and solution volume according to the principle of low or ultralow volume application.

3) Facilitation of aerial application or cooperative ground control by promoting group cultivation of bananas in suitable areas.

B. Crown rot

About NT$30 to 40 million is lost annually due to damage to bananas during shipment to Japan, and more than 60% of the damage has been caused by crown rot. This disease has been the chief complaint of Japanese importers in recent years. It was found that three pathogenic fungi, *Botryodiplodia theobromae, Ceratocystis paradoxa* and *Gloeosporium musarum* isolated from diseased Taiwan bananas are different from those in Central and South Americas, and our pathogen complex is much more virulent than the foreign one, as *B. theobromae* infects the banana in warm climate, while *C. paradoxa* invades the fruit in a cool condition. Therefore, it is harder to control crown rot in Taiwan than in the Americas. Vigorous efforts must be made to solve the control problem if we want to keep the superior position of Taiwan banana on the Japanese market.

For a long time, our banana fruit was treated with granosan for minimizing the crown-rot damage. Then in the summer of 1967, the Japanese Ministry of Welfare objected to the post-harvest use of this mercuric fungicide as a food additive because the chemical was thought to be noxious to human health. Thus, Fruit Marketing Cooperatives in different areas have stopped using it since the summer of 1968 in compliance with the Japanese request. Since Taiwan bananas during shipment to Japan can not avoid the attack of crown rot without preservative treatment, the Banana Importers Association of Japan suggested the use of Takasago Antiseptico or SPF, a chemical containing butyl p-hydroxybenzoate as an active ingredient, which is the only legal fruit preservative permitted by the Japanese Government. However, in trials these chemicals showed low effectiveness, considerable phytotoxicity and were difficult to handle. For the time being, we can not help using the chemical demanded by the Japanese Government. A new and more effective formula containing the legal chemical, which was recently developed by the Plant Pathological Laboratory of NTU, has been recommended for use in place of the aforementioned preservatives made in Japan. In our search for new chemicals both effective and easy of application, thiabendazol and benomyl have been found to be more effective and constant than the p-hydroxybenzoate preservative. The chemicals show no phytotoxicity and are highly effective against anthracnose, a serious market disease of banana. Moreover, they can be easily applied by dipping. It is expected that the use of the new preservatives will be accepted by the Japanese Government in the near future. Actually, the residue tolerance of thiabendazol in banana fruit has been cleared by USFDA.

In order to attain effective control of the disease, the following cultural practices and post-harvest treatments are recommended: (1) enforcement of Sigatoka control since the disease predisposes the fruit to crown rot; (2) improvement of fertilization, spacing and drainage because heavy dosage of nitrogen, high moisture content of soil and poor light condition are the predisposing factors; (3) proper packaging by using paper cartons instead of bamboo baskets for minimizing the bruising of fruit during transportation; and (4) improvement of the storage condition in refrigerated ships.

Citrus

A. Huanglungpin (Likubin)

The virus disease of Huanglungpin has become more serious as more than 40% of citrus trees died of virus attacks in 1958. In an etiological study made by the Plant Pathological Laboratory of NTU, the disease was identified as a tristeza-virus complex with seedling yellowing and stem pitting components which were transmitted by citrus aphids and grafting. The diseased trees would severely decline by showing the symptoms of leaf yellowing, defoliation, die-back and cease of growth. Further investigations revealed that the present disease was caused by an unknown component in addition to tristeza viruses. This unknown component is assumed to be closely related to greening virus reported from South Africa or leaf-mottling virus found in the Philippines, according to the symptom expression in some indicator plants and transmissibility of citrus psylla. The best way to check this virus disease is to use resistant stock-varieties selected from local and introduced varieties of citrus stocks through varietal test of resistance against the virus complex. In the preliminary tests, ponkan top-worked on trifoliate orange and rungpur lime was found to be tolerant to the virus complex, while sunki stock, currently widely used in Taiwan proved to be rather susceptible to the viruses although it was considered tolerant of tristeza components in North and South America and satisfactory as a rootstock for commercial varieties of sweet orange. In order to find virus-resistant rootstocks showing good horticultural characteristics, large-scale greenhouse screening and field trials with native and foreign stock varieties of citrus have been carried out jointly by pomologists and plant pathologists of NTU and some other institutions under JCRR-supported projects.

B. Black spot

The black spot disease infects citrus fruits and thus affects the citrus export because it mars the fruit appearance by damaging the fruit peel. The control measure currently adopted in Taiwan has failed to yield constant results. The ecological studies and field trials made by the Hsinchu Citrus Protection Experimental Laboratory revealed that the timing of fungicide spray cycles should be readjusted after every four to eight applications, since citrus fruits are susceptible to the infection up to the later stage of fruit growth toward green maturity, and the inoculum source remains dynamic with some peaks in late spring and summer for almost the whole year. Some systemic fungicides have been under testing with a view to lowering the spray cost by reducing the number of applications, as the causal fungus of latent infection may be brought under control by applying a few times therapeutants such as systemic thiabendazol and benomyl.

Green mold is also an important disease. It frequently causes losses by inducing fruit rot during shipment and marketing. However, it has been checked to some extent by having the fruit waxed before packaging. A post-harvest treatment of citrus fruits by dipping them in benomyl or thiabendazol solution has been initiated by the Citrus Protection Experimental Laboratory and NTU for more effective control.

Black Rot of Pineapple

Two types of internal post-harvest decay of pineapple are black rot or soft rot caused by *Ceratocystis paradoxa* and an internal browning of the fruit core (stalk rot) suspected of being caused by a complex of fungus pathogens. The black rot is most serious during shipment and marketing in Taiwan. The high rate of spoilage caused by the disease frequently found in shipments to Japan and other countries has affected greatly the export of Taiwan pineapples.

Contamination of the fruit by this causal fungus is widespread, since the pathogen is of polyphagia. The disease occurs under a long range of temperatures (15°-36°C), although the main causal fungus grows favorably at cool temperatures (15°-25°C). Presumably, this disease is caused by a pathogen complex including *C. paradoxa* and other microorganisms favoring high temperature. The etiological and ecological natures of the causal organisms, in addition to post-harvest physiology of the fruit, have to be clarified before an effective control measure can be formulated. According to a preliminary experiment made by Ogawa et al, the disease cannot be controlled by cold storage, for the main fungus can still grow at low temperatures. Therefore, an effective control measure will require the use of a fungicide. It has been found that the fungicide Benlate at 1.0 ppm of active ingredient suppresses mycelial growth in vitro completely. Benlate-treated stem-ends of pineapples are protected from the pathogen infection unless it is already established. The chemical in liquid-wax suspension gives better control of decay. At 800 ppm it was found effective but not at 400 ppm. The data suggest that Benlate can be used in water suspension as a whole-fruit dip or in wax as a basal fruit dip. But the treatment must precede infection.

Anthracnose of Papaya

Papaya is fast becoming an important tropic fruit for both local consumption and export. Its export cannot be further expanded unless the problem of fruitfly and anthracnose is solved. Anthracnose attacks papayas during shipment and marketing, thereby causing serious spotting and rotting. The pathogenic fungus, *Colletotrichum gloeosporioides*, also causes latent infection of the green fruit during the whole growing stage of papaya.

The ecological studies and fungicidal tests made by the Chiayi AES indicate that the causal fungus thrives in high temperature and the disease can be controlled by spraying Dithane M 45 on the tree and young fruit or having the fruit post-harvest treated in hot water at 43°-49°C. A semi-systemic fruit preservative like thiabendazol or benomyl might have the effect of control against the disease of latent infection. Therefore, this post-harvest treatment should be tested in the near future.

Some other tropic fruits, such as banana and mango, are also subject to the attack of the disease. The experimental data of fungicidal test mentioned above may also be applied to them.

List of Major Diseases of Main Export Crops

1. BANANA

   a. Crown rot 軸腐病
      Botryodiplodia theobromae
      Ceratocystis paradoxa
      Gloeosporium musarum

   b. Anthracnose 炭疽病
      Gloeosporium musarum

   c. Black leaf streak or Sigatoka disease 葉斑病
      Mycosphaerella musicola
      and/or *Mycosphaerella fijiensis*

   d. Bunchy top 萎縮病
      Bunchy top virus

   e. Black spot 黑星病
      Macrophoma musae

2. CITRUS

   a. Huanglungpin or Likubin 黃龍病
      Tristeza complex + Unknown virus component (Greening virus?)

   b. Black spot 黑星病
      Guignardia citricarpa

   c. Foot or/and root rot 裾腐病，根腐病
      Phytophthora spp.

   d. Green mold and stem-end rot 綠黴病，蒂腐病
      Penicillium digitatum
      Penicillium italicum
      Botryodiplodia theobromae

3. PINEAPPLE

a. Black rot 黑腐病
Ceratocystis paradoxa
b. Marbled fruit disease 花樟病
Erwinia ananas
c. Mealybug wilt 萎凋病
Dysmicoccus brevipes—transmitted virus-like substance

4. WATERMELON

a. Fusarium wilt 萎凋病
Fusarium oxysporum f. *niveum*
b. Anthracnose 炭疽病
Glomerella lagenaria
c. Mosaic 嵌紋病
Watermelon mosaic virus

5. TROPIC FRUITS

a. Anthracnose of mango 檬果炭疽病
Glomerella cingulata
b. Anthracnose of papaya 木瓜炭疽病
Glomerella cingulata

6. VEGETABLES

a. Yellow dwarf of onion and garlic 洋葱，蒜之萎縮病
Onion yellow dwarf virus
b. Purple blotch of onion 洋葱紫斑病
Alternaria porri
c. Tomato mosaic 蕃茄嵌紋病
Cucumber mosaic virus
Tobacco mosaic virus (Tomato form)
Potato virus X
d. Late blight of tomato 蕃茄疫病
Phytophthora infestans
e. Bacterial wilt of tomato 蕃茄細菌性萎凋病
Pseudomonas solanacearum
f. Soft rot of crucifer 十字花科植物之軟腐病
Erwinia aroideae
g. Sclerotinia rot of crucifer 十字花科植物之菌核病
Sclerotinia sclerotiorum
h. Mosaic of crucifer 十字花科植物之嵌紋病
Turnip mosaic virus
Cucumber mosaic virus
i. Stem blight of asparagus 蘆筍之莖枯病
Phoma asparagi

7. MUSHROOM

a. Weed microorganisms 雜菌（微生物）

Diehliomyces microsporus—Calves' brains
Scopulaniopsis fimicola—White plaster mold
Myriococcus praecos—Brown plaster mold
Dactylium dendroides—Cobweb disease
Fusarium oxysporum—Damping off
Bacteria
Nematodes

b. Brown spot 褐斑病

Verticillium psalliotae
V. malthousei

INSECT PROBLEMS OF MAJOR CROPS IN TAIWAN

David F. Yen

Insects are the most numerous of organisms in the animal kingdom. In Taiwan, approximately 16,000 species have been identified so far, and it is estimated that 35,000 more species exist on this Island. Some 1,500 of the 16,000 recorded species are known to be harmful to agricultural crops or products, with about 30 of the most important species causing millions of dollars of losses every year.

All insect species have a limited distribution range, and, characteristically, the insect numbers fluctuate to a greater or lesser extent both in time and in space. Occurrences of insect pests have undergone profound changes in Taiwan in the past twenty years. Such changes must have been resulted from the alteration of the environmental factors. The use of chemical insecticides has exerted a profound influence on the rates of change of insect numbers. For instance, following insecticidal application, many major pests (pineapple mealy bug, *Dysmicoccus brevips*, banana weevil, *Odoiporus longicollis*, paddy borer, *Tryporyza incertulas*, etc.) have been brought under control. On the other hand, some species (rice leaf-hopper, *Nephotettix apicalis*, *N. cincticeps*, rice planthoppers, *Nilaparvata lugens*, *Sogatella furcifera*, diamond back moth, *Plutella xylostella*, etc.) have become increasingly resistant to chemicals; while some minor species (rice striped stem borer, *Chilo suppressalis*, spider mites, etc.) have become major pests of today. Indicated in the following table is the change in occurrence of the major crop pests during the past years.

1948—1952	Up to 1962	Up to 1968
Rice insects		
Tryporyza incertulas	*Tryporyza incertulas*	*Chilo suppressalis*
Hispa similis	*Chilo suppressalis*	*Sesamia inferens*
Oulema oryzae	*Nephotettix cincticeps*	*Nephotettix cincticeps*
Sogatella furcifera	*Nephotettix apicalis*	*Nephotettix apicalis*
Scotinophora lurida	*Nilaparvata lugens*	*Nilaparvata lugens*
Tylorrhynchus heterochaetus		*Sogatella furcifera*
Dryland food crops insects		
Pseudaletia unipuncta	*Ostrinia nubilalis*	*Nesophrosyne* sp.
Ostrinia nubilalis	*Cylas formicaris*	*Heliothis zea*
Aphis maidis	*Heliothis zea*	*Tetranychus* spp.
Cylas formicaris	*Melanagromyza sojae*	*Etiella zinckenella*
Omphisa illisalis	*Tetranychus* sp.	*Cylas formicaris*
Gryllotalpa formosana		*Ostrinia nubilalis*
Gryllus mitralas		
Brachytrupes portentosus		

1948—1952	Up to 1962	Up to 1968
Vegetable insects		
Phaedon brassica	*Phyllotreta vittata*	*Plutella macalipinnes* (*xylostella*)
Phyllotreta vittata	*Brevicoryne brassicae*	*Pieris canidia*
Brevicoryne brassicae	*Pieris canidia*	*Pieris rapae*
Plutella maculipinnes	*Trichoplusia ni*	*Chaetodacus cucurbitae*
Prodenia litura	*Aulacophora similis*	*Holotrichia* sp.*
Agrotis ypsilon		*Euxoa segetis**
Pieris canidia		* in mountain areas.
Trichoplusia ni		
Aulacophora similis		
Pineapple insects		
Dysmicoccus brevipes		
Citrus insects		
Anoplophora maculata	*Panonychus citri*	*Dacus dorsalis*
Princeps demoleus		*Phyllocnistis citrella*
Toxoptera citricida		
Agrilus aurirentris		
Rhychocoris humeralis		
Chrysomphalus ficus		
Lepidosaphes beckii		
Parlatoria zizyphus		
Banana insects		
Odoiporus longicollis	*Cosmopolitans sordidus*	*Dacus dorsalis*
Cosmopolitans sordidus	*Dysmicoccus brevipes*	*Dysmicoccus brevipes*
Dysmicoccus brevipes	*Pentactonia nigronervosa*	
Pentactonia nigronervosa		
Tea insects		
Andraca bipunctata	*Chlorita fornosana*	*Chlorita formosana*
Homona coffearia	*Casmara patrona*	*Acaphylla steinwedani*
Ascotis selenaria	*Tetranychus telarius*	*Calacanis caunatus*
Eurpoctis pseudoconspersa		*Rihana achracea*
Mahasena minuscala		
Casmara patrona		
Chlorita formosana		
Odontotermes formosana		
Trachylophus sinensis		
Oligonychus coffeae		
Fiber crop insects		
Chlorita bigutula	*Heliothis zea*	*Anomia flava*
Earia fabia	*Chlorita biguttula*	*Heliothis zea*

1948—1952	Up to 1962	Up to 1968
Pectinophora gossypiella		*Chlorita biguttula*
Pysdercus megalophgus		
Mushroom insects		
	Mycophila speyeri	*Mycophila speyeri*
	Heteropeza pygmaea	*Heteropeza pygmaea*
	Megaselia sp.	*Rhizoglyphus phylloxerae*
	Bradysia sp.	
	Rhizoglyphus phylloxerae	

In the past 20 years, there has been a basic change in the method of control of crop pests in Taiwan. It can be traced to the introduction of the synthetic organic insecticides and the successful utilization of these materials in the early 1950s. Since then, about 50 kinds of insecticides of various types have been brought into use for insect pests control on this Island. The benefits, in term of economic gain, are inestimable. There can be no doubt that from the standpoint of human welfare the insecticide revolution has been a quite fortunate event. But, as is so often the case, the blessing is not an unmixed one. Problems have arisen, some quite serious, detracting from the benefits realized through using the new insecticides. This is in a large measure due to the fact that ecological considerations were essentially ignored in the development of these materials, and chemical, toxicological, and economic criteria were used instead. Pest control is largely an ecological matter. Consequently, modern insecticides, developed essentially without taking this into account, have with distressing frequency engendered serious problems through their disruptive impact on the ecosystems to which they have been applied.

It has become absolutely necessary that a fresh approach to pest control be undertaken and that this approach be essentially an ecological one. All persons connected with pest control must come to look upon artificial controls simply as tools to be fitted as unobtrusively as possible into the total environment to effect suppression of pest species at the times and places where they escape the repressive effects of natural control. All control practices, whether they be chemical, cultural, physical, or genetic, must be laced together with the existing components of the environment so as to be mutually augmentative and to bring about the most effective, least ecologically disruptive, pest control possible.

Since 1967, integrated insect pest control programs have been initiated on this Island with JCRR assistance. In the first two years, a total of 84 species of natural enemies including parasites, predators and pathogens of citrus insect pests, and 17 species of natural enemies of rice insects have been located and studied. Some of the promising natural enemies have been put to field trials. It is hoped that a safe, economic and effective program for the integrated control of insect pests can be formulated and adopted in the near future.

PRESENT SITUATION AND PROBLEMS CONCERNING THE USE OF PESTICIDES

Wei-Huai Horng

Types of Pesticides Used (1968)

Table 1 shows various types of agricultural pesticides now in use and their levels of toxicity to warm-blooded animals. Fungicides and insecticides of medium toxicity constitute the major pesticide types.

Supply of Pesticides

Except a small portion which is handled by the agencies concerned for emergency and educational uses or for stabilizing sale prices, most pesticides recommended by the government are supplied by formulator/manufacturers and importers through the commercial channel. The total sales in 1967 reached some NT$450 million. Table 2 shows the import and production of various pesticides in the past ten years. The following points are worth mentioning:

1) The total value of annual import has gone up from US$0.7 million in 1958 to US$6 million in 1967, showing an increase of about 8.3 times.

2) Import of fungicides increased from 15% of the total value in 1958 to 25% in 1967. Insecticides accounted for about 60%, and herbicides also registered a stead increase during the last few years.

3) Local formulation of pesticides initiated by JCRR in 1956 has been on the increase. Annual import of technical materials for formulation has been about 60% of the total value.

4) Local production is mainly composed of 73-200 M. T. of technical DDT, 432-2,000 M. T. of technical BHC and 50-200 M. T. of 2,4-D sodium produced annually.

Registration

Field trial and/or laboratory test are required for all pesticides intended to be sold in the markets before registration with the government. As of June 1968, a total of 1,486 pesticides from 45 formulators, 11 manufacturers and 70 importers has been registered, of which 1,328 with the Provincial Department of Agriculture and Forestry and 185 with the Taipei Municipal Government.

Quality Control

There is no pesticide law, and instead the following regulations in the nature of administrative orders have been enforced by the government to take care of quality control to some extent:

1) Regulations governing the registration, standardization and sales of

agricultural pesticides promulgated by the Taiwan Provincial Government in 1959 and revised in 1961.

2) Provisional standards of pesticides promulgated by the Ministry of Economic Affairs in 1961.

3) Standard requirements for the establishment of pesticide factories promulgated by TPG in 1961.

4) Measure for prohibiting the sales of inferior and false pesticides promulgated by MOEA in 1963.

In 1964 PID helped the government in drafting the first pesticide law, which was later finalized through a series of meetings with agencies concerned during a period of one and a half years. The draft law has recently been submitted by the Executive Yuan to the Legislative Yuan for consideration and approval after the former has made some changes on a few major points, such as deletion of the provision for interdepartmental administration of pesticide control, exclusion of household insecticides from the control, etc.

The control of pesticide quality was made possible by the establishment, with JCRR support, of the following laboratories:

1) Biological testing laboratory established in the Taiwan Agricultural Research Institute in 1957.

2) Physico-chemical laboratory established in the Bureau of Commodity Inspection and Quarantine in 1959.

3) Pesticide residue laboratory established in the Taiwan Hygienic Laboratory in 1964.

Pesticide administration has not been efficient so far mainly because of the lack of strict penalty provisions. However, efforts have been made by the government, at the suggestion of JCRR to eliminate the sources of disqualified products. To mention a few, the following steps have been taken:

1) Except registered factories, no technical grade pesticide is allowed to be imported for local formulation.

2) Imported pesticides in the form of finished products in large packages should be repacked into small sized ones by the registered factory, and prior approval by the agency in charge should be obtained.

3) The Police Bureau, the Bureau of Commodity Inspection and Quarantine and related agencies have participated in banning disqualified products from the markets.

Safe Use of Pesticides

Education on the safe and efficient use of pesticides has been carried out by PDAF with JCRR assistance since the early 1950's. The number of farmers poisoned by the chemicals during the time of application in the field has been reduced to a minimum. Detailed records of the poisoning cases are kept by the Provincial Food Bureau which supplies antidotes to all township health stations for giving free treatment to the affected.

Pesticide residue in/on vegetables is more harmful than in/on other food crops. The bioassay technique using standardized housefly as indicator has been adopted to determine the gross toxic level of pesticide residues in/on vegetable samples collected from the field two or three days before harvest. This method has proved effective in screening out vegetables suspected of contamination by the residues from pesticide application. If hazardous residue is found, the grower will be advised to delay the harvest until further test shows it is safe to do so. At present, there are 11 bioassay stations established with JCRR support in Sanchung, Chihu, Yunching, Yuanlin, Fengyuan, Hsilo, Tsaotun, Taichung, Chiayi, Matou and Pingtung.

The bioassay method is simple and it takes about four hours to complete an analysis, but it only tells the toxic level of residue in/on the sample without identifying the kind of pesticide used. JCRR has helped the pesticide residue laboratory in the study of pesticide residue determination. Recently a quick method for the identification and semi-estimation of 13 kinds of commonly used pesticides using a single procedure of thin-layer chromatography has been tried out. This chemical method is so sensitive that one to five micrograms of the residue could be easily detected in about four hours.

Moreover, investigations of pesticide residues in/on food crops have been made in connection with pest control research projects aimed at improving the protection techniques. Study on the development of a new method for determining EDB residue in/on citrus fruits is underway in hopes of solving the problem of residue on the treated fruits to promote the export of Taiwan Mandarin oranges to Japan. Study is also being made on the residue of maneb in/on bananas. This chemical is applied as a substitute for organo-mercuric compound in treating the fruit against crown rot infestation during shipment.

The question regarding the adverse effect of pesticide on the vitamin C content of some fruits and vegetables as shown by tests made by the Chihu Middle School and reported in a local newspaper on March 12, 1968, has been investigated by the pesticide residue laboratory. It was found that dieldrin, lindane, malathion, parathion and zineb representing chlorinated hydrocarbon, organo-phosphate and dithiocarbamate compounds would not decompose vitamin C in tomato, lemon and cabbage even at the concentration of 10 micrograms per milliliter within six hours. Only the inorganic copper compounds caused decomposition of vitamin C in the samples within one hour.

Initial deposit of pesticides on crops from aerial application by helicopter has been determined by the pesticide residue laboratory, and information thus collected can serve as a guide for safe and efficient use of the chemicals. This new approach to the problem was initiated by JCRR two years ago.

All in all, those who have engaged in crop production, pest control and pesticide toxicology and worked in a cooperative manner are clearing the path leading to further increment of crop production.

Table 1. Types of Pesticides Used in Taiwan (1968)

Pesticide	No. of types	Toxicity rating			
		Highly toxic	Toxic	Less toxic	Comparatively safe
Fungicide	58	10	17	15	16
Insecticide	48	10	29	6	3
Acaricide	13	—	10	2	1
Nematocide	3	—	3	—	—
Rodenticide	1	—	—	1	—
Herbicide	16	—	1	15	—
Plant growth regulator	7	—	2	5	—
Other	2	—	—	1	1
Total	148	20	62	45	21

Remarks: 1) Highly toxic: one of the following:
a) Acute oral toxicity to rat LD_{50} 50 mg/kg and below
b) Inhalation, 1 hour to rat LD_{50} 200 ppm and below
c) Skin penetration, 24 hours to rabbit LD_{50} 200 mg/kg and below
2) Toxic: 1/10 of (1)
3) Less toxic: 1/100 of (1)
4) Comparatively safe: lower than (3)

Table 2. Import and Production of Pesticides in Taiwan[1]

Unit: US$1,000

Year	Import[2]								Production Total[4]	Grand total
	Fungicide	Insecticide	Acaricide	Herbicide	Other	Technical grade	Finished product	Total		
1958	114	438	4	28	143	301	426	727	260	987
1959	52	555	10	7	92	345	371	716	220	936
1960	183	752	19	—	4	312	646	958	310	1,268
1961	278	841	16	9	8	297	855	1,152	539	1,691
1962	371	1,156	29	26	88	718	952	1,670	1,044	2,714
1963	509	1,275	50	60	89	675	1,308	1,983	554	2,537
1964	723	2,417	53	9	137	1,299	2,040	3,339	819	4,158
1965	989	3,354	35	150	183	1,965	2,746	4,711	763	5,474
1966	1,337	3,593	74	90	372[3]	2,868	2,598	5,466	828	6,294
1967	1,476	3,704	143	355	396[3]	2,560	3,514	6,074	1,100	7,174

1) Including household pesticides worth about US$10,000 to US$100,000 annually.
2) Breakdown both by kind and by technical grade material/finished product.
3) Including emulsifiers for local formulation.
4) Technical DDT, BHC and 2,4-D.

PESTICIDE ADMINISTRATION

Wei-Huai Horng

Regulations

Since the promulgation of the Taiwan District Pesticide Regulations by MOEA on October 24, 1968, the responsibility for pesticide administration has been transferred from the Taiwan Provincial Government to the Central Government. The former provincial regulations governing the registration, standardization, inspection and sales of pesticides issued on July 4, 1959 and revised on November 7, 1961 have been annulled. Both the new and old regulations are in the nature of an administrative order. The major differences between the national and provincial regulations are summarized as follows:

Item	New regulations (MOEA)	Old regulations (TPG)
1. Repacked pesticide as an item under control	Included	Not mentioned but taken care of by a separate administrative order
2. Registration of technical grade pesticide	Required	Not required
3. Limitations of pesticide retailers	Six categories only	Not mentioned
4. Statement of the effectiveness and phytotoxicity of pesticide to be included in the license	Required	Not required
5. Effective period of license	Four years	Unlimited
6. Government cancellation of the license due to health hazards or other important reasons	Included	Not mentioned
7. Common name of pesticide to be printed on the label	Required	Not mentioned
8. Restrictions on purchase of technical grade pesticide and repacking of finished product in big container	Pesticide factories only	Not mentioned but limited by separate administrative orders
9. Import of technical grade pesticide for formulation and application for license by government agencies	Upon MOEA's approval	Not mentioned
10. Import of non-registered pesticide for experimental, educational or emergency uses	Upon MOEA's approval but not for sale	Not mentioned
11. License plate for pesticide retailer	Required	Not mentioned
12. Retailer's record of sales of highly poisonous pesticides	Required	Not mentioned
13. Penalty	Warning and cancellation of license	Article 54 of the Contravention Code and cancellation of license

On November 4, 1968 a new administrative order for putting an end to the sale of inferior and falsely labelled pesticides was proclaimed by MOEA to supersede the Taiwan Provincial Government order issued on March 6, 1964 for the same purpose. The main differences between these two orders are summarized as follows:

Item	New order (MOEA)	Old order (TPG)
1. Repacked pesticide as an item under control	Included	Not mentioned but taken care of by separate administrative order
2. Non-registered pesticide solely for export not as a falsely labelled product	Permitted	Not mentioned but requiring approval by separate administrative order
3. Range of active ingredient content for falsely labelled pesticides	Not specified in the text	Exceeding twice the allowable limit as specified in the provisional standard of pesticides
4. Range of active ingredient content for inferior pesticides	Not specified	Not exceeding twice the allowable limit mentioned above
5. Pesticide as an inferior product if it causes plant injury when applied according to the labelled method of application	Defined as such	Not mentioned
6. Enforcement	Joint enforcement committee composed of representatives from the Taipei Municipal and Taiwan Provincial Governments, or county/city inspection teams	Provincial enforcement committee, helped by county/city governments to ban falsely labelled pesticides by order of TPG

Work to be Done

Many items of work required by the new pesticide regulations have not yet been started. So far, several meetings have been called by the Agriculture Department of MOEA to discuss this matter with the participation of representatives from such agencies as the Taipei Municipal Government, PDAF, BCIQ, TARI, the pesticide manufacturers and formulators' guild, CIECD and JCRR. However, the suggestions made at the meetings have not been put into practice because there is no one to assume the responsibility. It seems that the work will never get done without a responsible agency or body to take care of the whole business. Listed below are some of the items of work needed to be done:

1) MOEA license for registered pesticide. Article 12 of the new regulations authorizes MOEA to grant licenses to successful applicants for qualified pesticides. On October 24, 1968, MOEA, in an official letter, separately entrusted PDAF and the Reconstruction Bureau

of the Taipei Municipal Government to handle the registration and issuance of pesticide licenses on its behalf as was the case before the announcement of the new regulations. Because of the different requirements concerning the items to be registered for a license as stipulated in the new and old regulations, conflicts have occurred such as the difficulty in accepting the same trade name for two pesticides separately applied for registration with PDAF and the Taipei Municipal Government by two applicants (one in Taipei Municipality and the other in Taiwan Province). It has been repeatedly suggested that all pesticide licenses including the existing ones formerly granted by the two agencies before MOEA regulations became effective be issued or re-issued by MOEA in a uniform manner.

2) Name list of highly poisonous pesticides. Articles 15-1 and 19-7 of the new regulations require special labels marked with a colored drawing of skull and crossbones and a purchase and sales record to be kept by manufacturers/importers/retailers for all the highly poisonous chemicals. It was recommended but the list has not yet been officially announced by MOEA.

3) Registration of technical grade pesticides. Articles 11, 12 and 15 require that technical grade pesticides for formulation should be registered with the government with licenses to be granted for those already approved. Not a single technical grade pesticide has ever been registered because this requirement was not specified in the old regulations and no action for its enforcement has been taken so far.

4) Registration of pesticide retailers. Article 19 stipulates that any qualified pesticide retailer approved by the provincial or municipal government shall be granted a license plate showing his eligibility for running the business. As of the date of this report, the qualifications required of retailers have not even been announced.

5) Qualifications of pesticide retailers' technicians. Article 19 stipulates that MOEA should set up the required qualifications for the technicians of pesticide retailers and also the standard passing grades for use in the training of such technicians. But an announcement of these requirements has not yet been made.

6) Retailer's record of I. D. numbers of buyers of highly poisonous pesticides. This requirement as stipulated in Article 19-7 can only be enforced after a name list of these pesticides is officially announced by MOEA.

7) MOEA instructions for pesticide use. Article 23-2 authorizes MOEA to give directions on the "proper" uses of pesticides (the text does not read this way but seemingly implies so). This would mean that orders of this kind to be given in a standard form will be needed.

8) MOEA announcement of kinds of pesticides acceptable for registration. Article 23-5 requires MOEA to announce a list of acceptable pesticides for registration with the government. PDAF and the Taipei Municipal Government have repeatedly requested MOEA, but in vain, to make such an announcement because registration cannot be done without a list of the approved kinds, forms of preparations, range of active

ingredient content and combination of pesticides.

9) Range of active ingredient content for inferior/falsely labelled pesticides. Articles 5-8 and 6-1 of the MOEA regulations do not specify the limitations for the active ingredients of disqualified products. The banning of these kinds of pesticides will not be possible if such limitations are not officially established.

10) Joint enforcement committee for banning inferior/falsely labelled pesticides. Article 9 of the MOEA regulations states that a joint committee should be responsible for banning disqualified pesticides in the market. So far no action has been taken for the organization of this committee.

Problems

1) MOEA is responsible for the enforcement of the new pesticide regulations, but has not taken an active part in it so far. Except registration and issuance of licenses PDAF and the Taipei Municipal Government are not in the position to push other related activities. Closer coordination between these two agencies can hardly be attained merely by infrequent meetings called by MOEA. Discrepancy in handling applications for the registration have occurred. For example, PDAF has granted licenses for various concentrations of a pesticide to an applicant, while the Taipei Municipal Government has issued licenses for a pesticide under different trade names to another.

2) In the later part of 1968, violations of the rule on proper labelling for locally formulated or repacked products occurred frequently. Different labels with various colors, pictures or non-approved addition of a name of a place or shop for a registered pesticide bearing the same registered number were found on the containers in many local markets, even with a trade name for a pesticide other than the registered one. The situation became so confused that an immediate corrective measure, though justified, would be very difficult for the government to take because it would mean a big financial loss to the formulators/repackers who had produced these kinds of unauthorized products. A meeting was called by PDAF to discuss how the situation could be improved, which was attended by representatives of local formulators/importers. Persuasion seemed to be the only way out. The formulators/importers requested that corrective measures be put into effect only after they were allowed to withdraw all the unauthorized products from the market before the end of 1968 when the sales of pesticides were at a minimum and settlement of accounts was normally done between wholesalers and retailers. The situation was much improved on or about the end of last luner year, but the complete removal of these products from the market by the formulators was really a difficult task for them.

3) Registration of newer types of pesticides was suspended in the past eight months, because PDAF and the Taipei Municipal Government were only entrusted by MOEA to handle what had been registered before by them. This would mean that other types of pesticides did not have to be registered. Owing to the pressure of some formulators/importers requesting registration of newer pesticides, the two agencies were once in a very embarrassed position. This problem can not be solved

unless MOEA announces the list of pesticides acceptable for registration in accordance with the new pesticide regulations.

4) According to the new pesticide regulations, an applicant may send the sample of a pesticide directly to BCIQ for testing and then present a copy of the test report, if the result of test is satisfactory, to PDAF or the Taipei Municipal Government for registration. But according to BCIQ procedure, the test report together with a duplicate copy is mailed to the applicant directly. In this way the agency which handles the registration is kept in the dark as to whether the test report of pesticide is for registration or for other purposes, since BCIQ procedure for the test applies to all kinds of samples. BCIQ insisted on doing so for the procedure was set by the government. Better co-ordination can only be achieved if BCIQ is instructed by MOEA to make the necessary changes.

5) Pesticides suspected of being of inferior quality are sent by PDAF or the Taipei Municipal Government to BCIQ for testing and are handled by BCIQ according to the afore-mentioned procedure. If the test takes more than three months, the results of test cannot be used for final settlement according to the Contravention Code. Because of the insufficient number of BCIQ technicians (now only 4 persons) for pesticide analysis and their heavy workload, such a test usually takes more than three months. So, part of the samples had to be sent to government-operated pesticide factories for analysis. For proper enforcement of the new pesticide regulations, MOEA assistance in solving BCIQ's difficulties is deemed necessary.

THE ORGANIZATION AND TRAINING OF CITRUS GROWERS

Yu-Tso Cheng

For a special purpose and by a proper approach, the citrus growers in Taiwan have been organized and trained in accordance with the principles advocated by Dr. G. T. Lew, Consultant of JCRR. The following is a brief introduction to this important undertaking and its theoretical basis which has proved quite sound upon application:

1) According to Dr. Lew, the training of Taiwan citrus farmers is not necessarily a part of the agricultural extension work for the purpose of training is to promote overall agricultural development through coordinating the production plans of individual farmers with the government's agricultural policy. Hence it is both educational and economical in nature. The training program lays emphasis upon changing the farmers' old concepts and their conventional ways of farming, making them aware of the need for adjusting themselves to the changing world around them.

2) The attitudes and ways of living of Chinese farmers are strongly influenced by both Confucian and Buddhist doctrines. They place a high value on family ties and tend to resign themselves to fate. But such narrow, conservative beliefs help preserve the traditional moral values such as industriousness and frugality which are lacking among the farmers of many other countries. Against this background, the training program is an important means of not only teaching farmers modern agricultural techniques but also instilling into their minds the concept of democratic cooperation.

3) Dr. Lew maintains that the following principles must be adhered to in the training of Taiwan farmers:

a. No rules should be laid down for working out an organizational pattern, because conditions vary from area to area and the needs of one person may differ from those of another. If the objectives of organization are sound and correct, be sure not to let formality interfere with environmental demands, but to make the environmental demands decide on the forms of organization.

b. The items of work should not be pre-fixed for the farmers to follow. The same principle applies to the drafting of rules. Instead, the farmers should be encouraged to decide on the type of work they choose to perform and to draw up rules they are perfectly willing to observe. In a word, the farmers are not to be restricted nor commanded, but to be assisted by offering them all possible help and guidance.

c. Those young villagers who have had

a middle school education and are experienced in farming should receive training in modern agricultural techniques, for they can easily absorb what is taught on account of their educational background. Once trained they would return to their own villages to do re-training of their fellow villagers. Thus, more work can be done in less time.

d. The farmers are entitled to know all the problems involved in each production process from land preparation to marketing. When the whole picture is clear to them, they will try to settle the problems themselves.

4) With the support of JCRR, an experiment has been conducted with the citrus farmers. The following are some of the important activities successfully launched in the past decade.

a. In 1958, a Citrus Farmers Training Center was established at Hsinpu, Hsinchu County. The Center is equipped with modern training facilities which can serve as classrooms, laboratories or exhibition rooms. As of the end of 1968, over 1,000 citrus production team leaders and more than 900 young educated citrus growers received training at the center.

b. In 1961, a "local citrus growers production and marketing supervisory group" was formed by citrus farmers themselves in each principal citrus-producing area. The group members consist of outstanding citrus growers who are bent on improving the livelihood of their fellow growers.

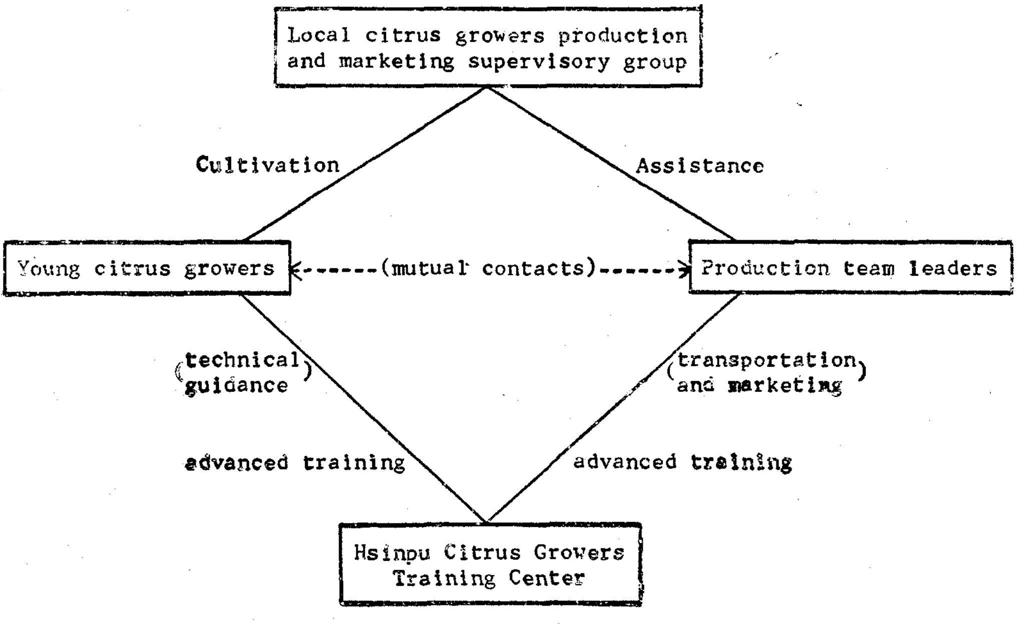
The size of each group depends on the location of citrus groves. A group may be set up by a single township, or by several townships. Each group raises its own operating funds and maps out its work plans. For example, the group at Tungshih, Taichung, has raised some NT$200,000 for promotion of citrus growers' education. The same group has established a "Citrus Growers Activity Center" and holds regular meetings to discuss the problems of citrus production and marketing confronting them.

The group at Fengyuan donated 1,000 "ping" of land for use as a packing lot to facilitate the marketing of citrus fruits. There are other groups working on the cooperative supply of pesticides and organizing mobile education units to help solve problems of citrus production. Altogether there are now seven such groups in the major citrus-producing areas.

c. Beginning in 1963, the young citrus growers who have received training at the Hsinpu Training Center are further trained in an "advanced class". There might be two or three classes at a township, or one class might be formed by two or three townships. The main purpose of holding such classes is to help the young promising growers better manage their orchards. They often meet to discuss and review their production activities for the purpose of further increasing their output. Their success has prompted other growers to make improvements in their orchards.

The 16 advanced classes in existence are all self-supporting. They even publish their own periodicals called "Young Citrus Growers." Some of the educated growers have pooled their resources for joint operation of citrus seedling nurseries, while others have been asked to impart their knowledge of "grafting" to fellow growers. There are instances of forming of partnership to open up new citrus groves in other areas without government subsidies for such ventures.

d. The inter-relationship between various organizations and the training of citrus growers is shown in the following diagram formulated by Dr. Lew:



Ten years have elapsed since the initiation of this project which has already exerted great influence on the citrus growers. As a result, the output, quality and export sales of citrus fruits have all improved steadily over the past decade. It is hoped that from this time on the same organizational work will attach more weight to "integrated cultivation" and "joint operation" in its approach to technical and managerial innovations.

TRAINING MATERIAL PROJECT FOR AGRICULTURAL RESEARCH AND EXTENSION WORKERS

Cheng-Seng Huang

For many developing countries of the world, one of the bottlenecks in agricultural development is the lack of enough well-trained research and extension workers. In this situation the few available scientists and administrators in the top positions must use a working staff whose education and experience are too inadequate to enable them to perform their jobs satisfactorily. Because of work pressure, the scientists and administrators often do not have time to train and supervise the work of their men themselves, with the result that many important research and extension efforts are wasted.

A solution to this problem may be found in providing pre-service and in-service training to the workers. Unfortunately, educational institutions cannot be of much help, as they may have their own limitations. On the other hand, the training effort of research and experiment agencies is often of an apprenticeship nature and their scientists may have neither the time nor well-prepared materials necessary for training their apprentices. These pose a problem as to how to establish efficient and economical training programs that can lead to the effectual continuation of the apprentice system.

Modern agricultural techniques have been successfully adopted in tropical and sub-tropical Taiwan in the setting of a small-farm economy, though similar problems have been experienced here.

The agricultural research projects in Taiwan have been so planned as to provide a chance of solving the problems faced by the majority of farmers. The organized approaches to research and extension in a pyramid form have made it possible for a well-trained scientist to lead a small group of college graduates in supervising a large number of bottom-level workers having secondary or basic-level education. Under this arrangement, on-the-job training of the lower-level workers in how to perform their duties correctly and efficiently has been emphasized.

The problem now is how to train these apprentices more scientifically and systematically. This entails sophisticated approaches and preparation of well-organized training materials. The training experiences at various stations and agencies, accumulated over the last fifteen years, have been on a person-to-person basis. It is now deemed appropriate to collect, evaluate, organize and strengthen such experiences so as to incorporate them into a master set of training materials. This would permit the limited number of well-trained scientists to work more efficiently and confidently on the unsolved agricultural problems of Taiwan. Moreover, the materials and approaches will be highly useful to similar training programs in other developing countries.

The basic idea of the present project was first conceived in 1964 by Dr. H. T. Chang, then Commissioner of Taiwan Provincial Department of Agriculture & Forestry. After several visits by IRRI scientists, a request for support of this project was made by JCRR to the Rockefeller Foundation in 1965. Some of the specific points of this project were: (1) to list the detailed steps necessary to carry out a field experiment or a demonstration for a given crop, (2) to indicate the possible pitfalls on each of the steps of operations to be performed and show how to avoid it, (3) to use specific visual and other appropriate instructional aids, (4) to provide lesson plans for different levels of training and to make self-instruction possible, (5) to provide appropriate background or reference material in the basic agricultural sciences. The form and content of the training materials would be such as to emphasize the behavioral changes in the trainees, permit trainers to screen individuals rapidly, allow continual upgrading or reinforcement, and recognize the importance of human relations and extension skills.

The intended trainees will consist of the research and field assistants of the experiment stations and the field extension workers. The trainers will most probably be the research project leaders and extension specialists having at least a B. S. degree. Basic references on agricultural processes, data on new technology, and information on how to use the training materials will be furnished. Because of the economical importance of crop production in Taiwan as well as in other developing countries, the initial development effort will be centered on rice research, extension and cultivation.

A working group composed of JCRR specialists and PDAF research and extension workers headed by Mr. C. H. Huang of JCRR was organized in 1965 for the implementation of this project. Guided by an outline on rice cultural practices and research skills prepared by Mr. Huang, the senior specialists of the various agricultural improvement and experiment stations, including Messrs. K. M. Lin and P. H. Lin of the Taichung DAIS, T. S. Lin and K. C. Su of the Tainan DAIS, Y. T. Hsieh of the Kaohsiung DAIS and L. D. Wu of PDAF presented their training experiences in a written form in Chinese in 1966. These papers were assembled and edited by Mr. H. S. Chang of JCRR. The manuscript entitled "Rice Cultural Practices and Conducting Field Experiment" was then translated into English by Messrs. C. S. Huang, W. L. Chang, Y. L. Wu and S. K. Chang in the spring of 1967.

In the meantime, Mr. John H. Lindt, consultant of this project invited jointly by JCRR and IRRI, started to work on the paper at JCRR in February 1967. The manuscript was rewritten in a "how-to-do-it" style and was expanded to make it applicable to rice culture in all of Asia under the title "Methods of Rice Culture and Field Research". It consists of four parts, namely, basic concepts and principles, rice production skills, field experiments, and special rice experiments and techniques. The first draft, except part I, was completed in February 1968 when Mr. Lindt could not extend his stay in Taiwan and left for the United States. One copy of this manuscript, including illustrations and pictures, was sent to IRRI for review and comment.

IRRI scientists also prepared a set of training materials for the Workshop on Field Experimentation with Rice held from February to April, 1968, at IRRI. These materials were later incorporated into the "Methods of Rice Culture and Field Research", particularly to fill up the first part: basic concepts and principles. Corrections on other parts were made according to the suggestions of IRRI specialists and others.

Numerous illustrations and pictures were inserted in the proper places of the book with necessary explanations. The contents of the said book are listed as follows:

METHODS OF RICE CULTURE AND FIELD RESEARCH

PART II. RICE PRODUCTION SKILLS

3.2. Analysis, Grading and Calculation of Fertilizers
3.3. Fertilizer Storage
3.4. Method of Fertilizer Application
3.5. Making Compost Manure
3.6. Incorporation of Composts and Green Manure
3.7. General Rules of Soil Sampling

4. Pest Control

4.1. Disease Control
4.1.1. Blast
4.1.2. Stem Rot
4.1.3. Brown Spot
4.1.4. Sheath Blight
4.1.5. Bacterial Leaf Blight
4.1.6. Bacterial Leaf Streak
4.1.7. Virus or Virus-like Diseases
i. Hoja Blanca
ii. Transitory Yellowing
iii. Tungro
iv. Yellow Dwarf
4.2. Insect-Pest Control
4.3. Control of Other Pests
4.4.1. Classification of Agricultural Chemicals
4.4.2. Selection and Purchase of Agricultural Chemicals
4.4.3. Calculation of Pesticides
4.4.4. Mixing Agricultural Chemicals
4.4.5. Storage and Disposal of Agricultural Chemicals
4.4.6. Sprayer Calibration
4.4.7. Knapsack Sprayer Method
4.4.8. Use and Maintenance of Power Sprayers
4.4.9. Use of Hand Dusters
4.4.10. Use of Power Dusters
4.4.11. Safety Margin
4.4.12. Disease and Insect Forecast

5. Seed Production and Inspection Method

5.1. Seed Multiplication
5.2. Determination of Acreage Needed for Seed Production
5.3. Rouging
5.4. Inspection and Sampling
5.5. Laboratory Analysis and Testing
5.6. Tagging and Distribution

6. Diagnostic Skills

6.1. Tools Needed
6.2. Diagnosis of Field Problems
6.3. Soils and Nutritionally Induced Disorders
6.4. Physiological Disorders
6.5. Major Insects of Rice

PART III. FIELD EXPERIMENTS

1. Scientific Methods
2. General Considerations and Preparation for Field Experiments
   - 2.1. Definition of Investigational Objective
   - 2.2. Review of Past Experiments
   - 2.3. Choice of Method to Meet Objectives
   - 2.4. Specification of Data to be Collected
3. Experiment Design and Plan
   - 3.1. Selection of Treatments or Practices
   - 3.2. Selection of Plot Size and Shape
   - 3.3. Selection of Number of Replications
   - 3.4. Selection of Experiment Design
   - 3.5. Assignment of Plots
   - 3.6. Preparation for Statistical Analysis as a Step in Experiment Design
   - 3.7. Budget, Time, Personnel, Equipment and Cost
   - 3.8. Preparation of Experiment Plan and Map
4. Establishment of Field Experiment
   - 4.1. Preparation of Field Record Book
   - 4.2. Selection of Site
   - 4.3. Selection of Plant Materials
   - 4.4. Field Layout—Making and Stating Your Trial
   - 4.5. Identification of Field Plots
   - 4.6. Treatment Applications or Other Variables
5. Management of Field Experiments
   - 5.1. Land Preparation
   - 5.2. Seed Preparation
   - 5.3. Nursery Management
   - 5.4. Transplantation
   - 5.5. Application of Green Manure and Compost to Experimental Areas
   - 5.6. Application of Fertilizers
   - 5.7. Insect and Disease Control
   - 5.8. Weeding and Rouging
   - 5.9. Bird Control
   - 5.10. Rodent Control
   - 5.11. Water Management
   - 5.12. Harvesting
   - 5.13. Determination of Straw Weights
   - 5.14. Threshing
   - 5.15. Winnowing
   - 5.16. Alternative Methods of Harvesting
   - 5.17. Determination of Moisture Content of Grain at Harvest
   - 5.18. Adjustment and Storage of Experimental Materials
6. Measuring and Recording Data
7. Statistical Analysis of Experimental Data
   - 7.1. Establishment of a Mean