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DEVELOPMENT AND MANUFACTURE OF MECHANIZED RICE GROWING EQUIPMENT IN TAIWAN 1/

by

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I. Introduction

About half of the cultivated land in Taiwan is devoted to rice growing, and so the development and manufacture of rice-farming machinery and implements are given the highest priority. In the past decade or so, steady improvement has been made on the mechanization of farming operations to keep pace with the agricultural development in this island province. However, the development of agricultural machinery/implements is a slow and gradual process because they not only have to adapt to the local conditons such as climate, types of land and soil, kinds of crops and farmers' readiness to adopt mechanical farming, but also benefit greatly the existing intensified cropping systems practised in Taiwan.

With the exception of pedal thresher, paddy field weeder and the improved animal plow, which were the modified forms of those introduced from Japan, most of the rice-farming implements in use in Taiwan are exactly the same as those use in mainland China. Statistically speaking, about 77 percent of the rice cultural implements is directly introduced from the mainland, 15 percent from other countries, and only about 8 percent was developed locally. For several centuries there was very little change in the designs of farm implements, but since the Joint Commission on Rural Reconstruction (JCRR) came on the scene in 1952, a blueprint for farm mechanization was drawn and has been carried into action ever since.

This paper attempts to describe briefly the processes of modernizing farm machinery and implements, especially for rice culture in Taiwan, in addition to the related events leading to the development of mechanized rice farming in Taiwan.

II. Background and Conditions of Rice Farms in Taiwan

A. Land and soil:

Besides the island of Taiwan and its 13 offshore islets, there are 64 islets in the Penghu group, known as Pescadores. The total area of Taiwan is 13,885 square miles, and the distance from the north to the south ends is 246 miles and that from west to east 90 miles. The Tropic of Cancer crosses the island just south of the middle of the island.

The central mountain range divides the island into eastern and western parts. In the west there are gentle slopes and fertile plains, while in the east the terrain is rugged with steep slopes. The mountain areas cover approximately two-thirds of the island, and the main cultivated land lies in the western part of the island.

Of the total 902,406 hectares of cultivated land, 537,547 hectares are paddy fields. The rice crop is usually grown on the alluvial soil either in the plain or along the river valleys. The paddy soil of slate and sand-stone origin is rich in plant nutrient, while those of saline alluvium is generally inferior in soil fertility. Rice is also grown on the tableland lateritic soil where irrigation is available.

B. Climate and water:

The annual mean temperature is 21.6°C at Taipei in the north and 24.5°C

at Kaohsiung in the south. The highest temperature is 38°C and the lowerest 1°C. In the summer months, the temperature along the coast is almost identical (around 28 - 30°C). The summer usually lasts from May to September, and winter is short and mild lasting from December to February.

The monsoon usually brings in enough rainfall, averaging 2,500 mm a year. Its distribution, however, does not fit in well with the growing season of rice on the island as a whole. Roughly speaking, the high mountain range lying between the Suao Township (east coast) and the mouth of the Ta-an River (west coast) divides the island into two different regions in so far as the raining season is concerned. In the northern part, a strong northeast monsoon blows steadily during the period from October to March, bringing to this area a prolonged rainfall, which facilitates the growing of rice; but if the long-drawn rainy days intercept the harvest season, it may cause various degrees of grain loss. In the summer months, when southeast monsoon prevails, plenty of rainfall accompanied with thunderstorms in all parts of the island furnished the second crop rice with irrigation water.

It is estimated that a total of 8,800,000,000 cubic meters of rain water fell on this island annually. Of this amount, 21 percent were harnessed for irrigation and/or for generating power. Well developed reservior and canal systems are now under the administration of 26 irrigation associations throughout the island. With a total of 788,635 rice-crop hectares, about 92 percent of which is irrigated (including reservior and deep well irrigation) while the other 8 percent is rain-fed.

C. People and crop:

According to the history of Taiwan, the Chinese settlers began to make use of irrigation water to raise rice in the early Ming Dynasty (1279 - 1368). Around 1661, the Chinese immigrants who came to Taiwan in large numbers brought with them many mainland rice varieties for food raising. These varieties are known as indica-type or commercially called native rice. Besides rice varieties, rice-growing equipment were also brought in by the immigrants. In 1899, the Japanese introduced a number of rice varieties from Japan which were the parent stocks of Ponlai rice varieties which are cultivated extensively in Taiwan today.

The development of new rice varieties coupled with increased fertilizer application, proper pest control, efficient irrigation systems and other improved measures accounts for the record yields in recent years from two rice crops raised per year. Though the planted area of rice is only about 540,000 hectares, the yearly output is not only sufficient for local consumption but also leaves a sizable amount for export.

D. Farm size and family:

The land holding per household in Taiwan is about 1 hectare on an average as shown in the following table:

Table 1. Number and size of rice farms in Taiwan (1960)

Size of land holdings	No. of rice farms
Under 0.5 ha	179,760
0.5 - 1.0	185,940
1.0 - 1.5	103,750
1.5 - 2.0	57,190
2.0 - 3.0	45,210
3.0 ha & over	22,240

A unique feature of land holdings in Taiwan is that a form does not necessarily consists of one single plot, but in a number of plots averaging about 0.1 - 0.2 hectares per plot. This is due partly to the centuries-old custom of equal share of land among all the sons of a family. Thus, the consolidation of rice fields into large plots is therefore not feasible. Any machine that can work in small fields must be compact enough and be able to make small turns.

E. Farmers and the cropping systems:

After the implementation of the land-to-the-tiller program in Taiwan, the tenant farmers who have become land owners are working doubly hard, thereby increasing greatly the land productivity. This psychological factor is applicable to the ownership of machines as well. When a farmer owns a machine, he will take good care of it and try to use it to the fullest extent.

In Taiwan, many other crops than rice are raised by rotation. In the rice-growing areas, wheat, tabacco, soybean, flax, sweet potato, peanut, corn, jute, sorghum, etc. are also grown. Therefore, farmers need a multi-purpose machine to work not only in the paddy fields but also in the fields for raising other crops, as the existing cropping system requires inter-row deep cultivation after the preceding crop is harvested. So a machine should be maneuveable between the cropped rows.

III. Development and Popularization of Rice-farming Machinery in Taiwan

A. Introduction and improvement of rice-farming machinery

1. Water pump:

Water pump was introduced into this island from Japan about 50 years ago. However, its usage is somewhat different from other countries on account of the intensive farming patterns adopted, for the rice fields have to be irrigated or drained very often in order to grow other crops. Sometimes large pumps are used, but most of the time the use of small centrifugal pumps driven by 3 - 5 hp kerosene or diesel engine is sufficient, for it can easily be moved to any other places. It was during the time when farmers began to realized the advantages of using water pumps, several small machine shops were engaged in producing the machine by importing oil engines from Japan. This is considered the beginning of rice machine manufacture in Taiwan. Evidently the history of Taiwan's agricultural machinery industry is comparatively young among other industries in Taiwan.

After World War II, the local machine manufacturers turned out about 2,000 units of pumps annually for meeting the local requirements. At present, it is roughly estimated that about 50,000 units of the machine including deep well pumps are owned by farmers for irrigation purpose. Now more than a dozen small local manufacturers are producing the machine for local use and export to other countries.

2. Sprayer:

Before 1953, besides a government-operated plant turning out hand sprayers on an experimental basis, there were 874 small family-sized factories or machine

shops engaged in the manufacture of the hand and animal-drawn tools. Sprayers and dusters used in Taiwan were mostly imported from Japan; they were in small number as chemical spraying for control of rice insects and diseases was not widely practised then. Only when the application of Parathion and Endrin for controlling rice borers was widely practised, did the demand for sprayers have a rapid increase. Since then, more than a dozen private factories have been established to manufacture both sprayers and dusters, including some power sprayers.

Up to 1960, the rice growers were buying more than 10,000 units of hand sprayers a year. And in 1960, there were 104,150 units of hand sprayers, 10,803 units of hand dusters, 264 units of power sprayers and 53 units of power dusters in use in rural Taiwan. Today, about 200,000 units of sprayers, 25,000 units of hand dusters, and some 14,000 units of power-driven sprayers and dusters are owned by local farmers. Furthermore, a small number of hand sprayers are being exported to other countries. During 1967-68, the sprayers and dusters mounted on helicopters for aerial pesticide application over paddy fields were employed by the government and farmers' associations.

3. Power tiller:

Early in 1953, when the first 4-year agricultural production plan was underway, there were some 400,000 head of draft animals, most of which were water buffaloes. The number of cattle was far from sufficient, and 100,000 head more were needed for intensive cultivation. However, it was very difficult to get the required number of animals in a short time. Even if it is possible, each animal needs 0.8 hectares of land for growing feedstaff, so a total of 80,000

hectares have to be diverted from food-growing, when more and more land is needed for feeding the teeming millions on the island. And when the total amount of work done during the lifetime of a buffalo is tallied against the total cost involved, it is far from economical as compared with the mechanical power. Therefore, only through using power farming equipment can the problem of rural power shortage be solved once for all.

As an attempt to solve the problem of anticipated labor shortage, seven different makes and models of garden tractors in the power range of 1.5 - 10 hp were introduced into Taiwan by JCRR from the United States in 1954. In the following year, a 5 hp rotary-type and a 2.5 hp tiller-type single-axle two-wheel tractor now called "power tiller" were purchased from Japan. They were tested at various agricultural research and improvement stations and agricultural schools, thus marking the beginning of power tiller extension in Taiwan.

The rotary-type tiller was the typical diesel-engined tiller developed and popularly used in Japan over the past three decades. A smaller one was originally an American design but remodelled and improved for use in irrigated paddy field in Japan. It is compact and light and simple in construction. From the preliminary tests, both of the machines showed their outstanding performances in irrigated rice field, especially the smaller one which has found acceptance with the local rice farmers, because of its high versatility and low cost. Moreover, it can perform various farming operations, such as tillage, transportation and cultivation.

In 1956, JCRR again imported a quantity of small power tillers of the same type for testing and demonstration at the agricultural stations. At the time of

demonstration, the local farmers showed at the onset their interest in the machine, and their demand for it became so strong later that the local machine manufacturers began to produce the machine by copying the imported models. Several small farm machine shops added this machine to their stocks. A number of factories formally making motorcycles or small oil engines produced power tillers as a sideline production. Up to 1959, a total of 22 small manufacturers came into being and began producing locally-made power tillers. Most of them concentrated on making the tractive-type power tiller, and only two plants produced the driven-type rotary tillers. In the meantime, the imported power tillers increased to 16 different brands, offering a strong competition to the local manufacturers.

However, the small manufacturers, whose products were of doubtful quality and some of them built only a few units, soon found them in financial straits. Thus, owing to insufficient operating funds and for lack of proper manufacturing techniques, all the local manufacturers, except three, either went bankrupt or changed to making other products at the end of 1960. The three remaining manufacturers have managed to turn out a small number of power tillers each year. On the other hand, two groups of Taiwan industrialists, in cooperation with Japanese agricultural machinery companies, set up two factories to produce power tillers with some parts imported. From this time on, the import of power tillers except spare parts, stopped altogether.

In Taiwan today, mechanization of land preparation is no longer experimental, but it has become well established by the wide use of power tillers mostly in paddy fields. It is ideal for land preparation on water-logged soil since it adds

traction to the propelling unit rather than retarding it. The growing number of power tillers used on Taiwan followed by the steady decrease of draft animals is shown in Table 2.

Table 2. Number of power tillers and draft animals in Taiwan

Year	No. of power tiller						No. of draft animals
	Total	Manufacture		Horsepower			
	(unit)	Made locally (%)	Imported (%)	Under 5 (%)	5 - 8 (%)	Above 8 (%)	
1954	7	0	100				406,172
55	9	0	100				412,018
56	60	5.00	95.00				412,440
57	180	34.44	65.56				412,346
58	600	35.16	64.84				416,368
59	2,262	57.07	42.93				417,159
60	3,709	46.17	53.83	34.87	38.59	26.54	417,122
61	5,313	41.05	58.95	26.71	45.66	27.63	414,208
62	7,504	46.74	53.26	21.60	49.95	28.45	405,056
63	9,079	51.90	48.10	19.23	53.25	27.25	389,448
64	10,201	57.04	42.96	17.67	50.91	31.42	379,973
65	12,213	63.15	36.85	15.88	50.52	33.60	370,370
66	14,272	68.46	31.54	14.28	49.37	36.35	360,294
67	17,240	73.80	26.20	13.13	42.52	44.35	337,978
68	21,153	78.61	21.39	11.60	35.15	53.25	323,085

A total of 21,155 units of power tillers were used before the end of 1969. Since the cultivated area totals some 900,000 hectares and the total farm households numbered about 868,000 in Taiwan, there is approximately a power tiller on every 42 hectares of land and owned by every 41 farm households. Though the increase of power tillers in Taiwan is far from being impressive, yet, since 1961, the draft cattle have decreased in number at the rate of more than 10,000 head annually to be gradually replaced by mechanical power.

4. Artificial grain dryer:

It goes without saying that adquate rain-water hastens the growth of various crops, particularly rice, but when long-drawn rainy days intercept the harvest season, the full grown rice in the field or the newly-harvested grains spread on the drying ground may sprout and cause various degrees of damages.

According to an island-wide survey by the Provincial Department of Agriculture and Forestry (PDAF) in 1954, the rice grain loss per hectare due to spreading, turning, winnowing, etc. on the drying ground was 28.8 kg. However, the actual annual rice loss throughout the whole island would be much higher, because the harvesting time of the first rice crop in southern Taiwan and that of the second rice crop in the north usually fall in the rainy season. When the rain comes in the midst of harvesting, the farmers have no choice but to pile the brown rice on the drying ground and cover it with straw and pray for the end of the foul weather. If the rain lasts several consecutive days, the wet grain pile will gradually warm up from heat accumulation due to transpiration. The temperature in the center of the pile will thus go up, resulting in fermenting, sprouting or molding. Heavy damages to rice were reported in 1964 and 1965 in the Ilan area of northeast Taiwan

where the rain lasted 50 days and 20 days, respectively, right in the harvest seasons.

In the southern part of the island, though the rainfall is not too heavy in the harvest season, it usually comes every afternoon, and so only half the day can be used for rice drying. But, in the early June of 1966, the paddy rice in the said area suffered heavy damage due to the incessant rain which continued for 20 days right in the middle of the harvest season.

In order to save a sizable amount of rice from spoilage by rain or high humidity, several types of rice dryers were purchased from the United States by JCRR for trial use during the past decade. These are: a portable rice dryer made by the Behlen Manufacturing Co., a column type rice dryer by the American Drying Systems, Inc., and a small portable rice dryer by the American Drying Equipment Co.. The preliminary tests have revealed that the Behlen portable dryer gave the lowest drying cost, while the other two produced rice of better quality. However, all these dryers are either too bulky or too expensive for the individual farmer to practise or to own. A lighter drying bin with a motor blower and burner for artificial drying of rice was developed for extension by the PTF experiment stations in cooperation with the China Agricultural Machinery Co., Ltd. in 1966. The description of this bin-type artificial grain dryer is as follows:

The dryer is portable, weighing about 270 kg. In the ordinary harvesting time, the grain dryer could reduce the moisture content of grains from 20 to 13 percent and turns out about 1,500 kg. of dry rice every 12 hours. In the rainy harvest season, the dryer could even be operated 24 hours a day. The fuel for the burner of the dryer is of coke or kerosene, while the $\frac{1}{2}$ hp motor blower uses electricity as the source of power. About 650 units of the dryer have been extended

to local farmers for adoption during the past two years. Meanwhile, some 300 units of Japanese-made dryers of the similar design were also imported.

5. Rice transplanter:

Rice transplanting in paddy fields is still done manually in Taiwan. For facilitating the operation, only a rolling disk-type marker is available for marking both directions across the field for straight planting. It is nevertheless a piece of back-breaking and time-consuming work. According to a study on the labor-hour requirement per unit farming operation of eleven crops in Taiwan conducted by the Agricultural Engineering Department of National Taiwan University, about 19 percent of the total labor hours required for rice culture is devoted to the transplanting operation.

However, progress has been made in the mechanization of rice culture. In the busiest season of rice transplanting, farmers still feel the shortage of labor, higher personnal expenditure and declining productivity, for the labor force in the rural areas is being gradually absorbed by the mushrooming industry.

Since 1966, JCRR has assisted the Taipei District Agricultural Improvement Station in modifying two Japanese rice transplanters - a motor-driven type and a hand-pushing one - according to our needs and agricultural conditions. The preliminary results obtained from the experiment conducted in 1967 for evaluating the effect of the newly improved machine on transplanting is very encouraging, as the transplanter can save two-thirds of the labor required for seedling nursery, and is four times quicker in transplanting than hand transplanting. In addition, the yield in the mechanically-transplanted plots was higher than that of the hand-transplanted crops. Presumably the increase was due to such factors as:

a) more healthy seedlings; b) uniform planting depth of the seedlings; c) wide-row and close-hill spacing; and d) even number of hills. The comparison between the transplanter and the conventional method is as follows:

Table 3. Comparison between transplanter and the conventional method

Items	Transplanter		Hand transplanting	
	2nd crop 1967	1st crop 1968	2nd crop 1967	1st crop 1968
1. Spacing(cm)	36.9x13.6	30x12	22.5x22.5	22.5x22.5
2. Plant height at ripening stage(cm)	102.71	113.35	98.59	112.20
3. Panicle length(cm)	19.09	18.98	19.10	18.31
4. No. of valid tillers per hill (tillers)	11.59	13.31	12.76	13.88
5. Panicle weight(gr)	1.65	2.12	1.44	2.02
6. Grain yeild(kg/ha)	3,258	5,012	3,006	3,859
7. Time for preparing seedbed (hr/ha)	24.1	37.1	38.5	79.0
8. Duration of seedling nursery (day)	15	30	30	50
9. Time for transplanting (hr/ha)	28.1	33.2	115.7	108.0

The use of the transplanter is also helpful to the extension of the newly developed wide-row and close-hill planting system in rice culture which is capable of increasing the rice yield by more than 10 percent as compared with the commonly

practised square-shaped spacing.

In order to accelerate the general adoption as well as to show the advantages of using the transplanter in rice culture, JCRR and PDAF jointly helped the China Agricultural Machinery Company produce the machine. In 1968, several units of them were built and sent to concerned agricultural stations for field tests. Beginning in this year, some 50 units of the machine have been constructed and set to five Township Farm Mechanization Promotion Centers for demonstration and training. Judging from the good results of using the transplanter, it is a matter of time that mechanized transplanting of rice will be widely adopted by the local rice farmers.

6. Rice harvesting machine:

In Taiwan, the paddy is still harvested with a small, lightweight hand sickle. Pedal thresher with a threshing cylinder mounted on skids are pulled around the field to follow the reapers. One man can cut about one-half acre per day with a sickle, and two men with a pedal thresher can thresh two or three tons of paddy in a day. After threshing, the grain is carried to the courtyard for drying, winnowering and cleaning on concrete grounds.

Thresher driven by a small gasoline engine instead of a pedal has been developed and widely adopted by local farmers in recent years. In the meantime, a small number of Japanese type power threshers are for trial use.

In 1967, two kinds of hand reapers, pushing and pulling, modified from Japanese designed ones were manufactured locally for extension. However, they have not been extensively used so far due to higher grain loss and other drawbacks. So, the production of the pushing type reaper was abandoned. To adopt this device

will require either a new variety of rice or a change in the field size, as the present rice varieties in Taiwan were developed for easy threshing by manual labor. The straw is tough and flexible and the grain shatters very easily, thus even a simple cradle can not be profitably used because the grain will be shattered by the impact of the cradle fingers.

Recently, a number of Japanese small rice combines consisting of a reaper and an ordinary power thresher, were introduced by the local farm machinery manufacturers for trial use. However, several short comings of using the machine have been found. They are:

a. The grain shatters very easily as the cutting and gathering devices of of the machine are not gentle enough to keep the grain intact.

b. The gathering mechanism of the machine failed to gather up all the lodging stalks.

c. Most of the fields are too soft at the harvesting time to support the heavy machine.

d. The small uneven fields of Taiwan makes the use of the combine unpractical and less efficient.

e. The machine would not operate well especially its cleaning device when the moisture content of the grain is too high during such operating times as the early morning or after rainfall.

6. Weeder or cultivator:

In large-farm countries, weed control in the paddy field is no more difficult than in other crop fields. Yet, in Taiwan, most of the weeding operation is still done by hand. The hand-operated rotary weeders originally introduced

from Japan is now made exclusively in Taiwan for the sandy soil in which the paddy rice is planted in check-rows. So far, about 37,000 units of the weeders are in use in rural Taiwan. It has one or two rotors mounted on a small boat-shaped farmework and a handle for a farmer to push. This weeder can work on 0.3 to 0.4 hectares of paddy field per day.

7. Fertilizer applicator:

It is a common practice of Taiwan farmers to apply chemical fertilizer by hand. The fertilizer is put either in a basket or in a sack which is hung on a farmer's shoulder by means of a strap. The farmer takes a handful of the fertilizer and broadcasts it by hand on the field as top dressing.

Up to present, no suitable mechanized fertilizer applicator is available. Chemical fertilizers used in Taiwan are mostly of straight types and in powder form. Mechanical application of them in mixture poses a technical problem. However, it can be applied by a mist-blower if granulated fertilizer is used.

There are no manure-spreading machine available for local rice culture. The use of a manure fork is the only means to spread manures in the paddy field before plowing as compost manure is only used for basic application. The manure fork in use was imported from Japan about 10 years ago. Now, there are two tool factories producing the instrument for the local market as well as for export.

8. Grain cleaning equipment:

Paddy grains after drying up have to go through a winnower once or twice before sending to the market. The winnower is generally made of wood, but some factories are producing winnowers made of sheet metal. A revolving fan inside of it is cranked by hand to produce an air blast for removing the chaff, straw,

dust and unripe grains. Plain bearings are usually used in the revolving mechanism. Only in recent years ball bearings have been adopted by the manufacturers. On an average, 180 hectoliters of paddy can be cleaned by a winnower on a one-run basis.

Since electricity is afailable in most of the rural areas, some winnower manufacturers have developed a electric motor-driven winnower to replace the hand-cranked one. Some of them are even equipped with an auger elevator to transport the grain into the hopper of a winnower at higher speed with less labor.

9. Rice processing facilities:

Rice hulling and polishing equipment is mostly under the management of the local farmers' associations to serve all the farmers in the respective areas. The machine equipped with an oil engine or a electric motor of 7 to 12 hp has a capacity of hulling and milling 2 to 4 metric tons of brown rice per hour. Recently, a number of smaller rice hullers and polishers have been adopted for individual and/or cooperative use by the farmers.

B. General problems faced and measures adopted for machinery extension

1. General problems of mechanized rice-farming:

The mechanization of small-farm agriculture in Taiwan may serve as an example for countries with similar condition. The problems we have been facing at the beginning of mechanized farming are briefly stated as follows:

a. Small farms and fragmentation of land:

As the average size of farms in Taiwan is about one hectare, the use of large type machinery is, of course, impractical and costly.

b. Diversified and intensified cropping systems:

Almost all the small farms are managed in a diversified way, without

much use of specialized machinery. And in the intensive cropping system, farmers grow one crop after another, and practice relay-interplanting before harvest of the previous crop. For this reason, compact machines that can easily travel between rows are what the farmer need now.

c. Low purchasing power of individual farms:

Low puchasing power is a common phenomenon in countries with small-farms predominant. This is mainly due to the limited farm produce, simple and inefficient tools employed and production for family use, but not for marketing. Thus, it is doubly hard to market farm machinery among the farmers with low purchasing power.

d. Farm population not mechanically minded:

Individual farmers are, as a rule, devoid of mechanical sense. This is also a bottleneck to farm mechanization that should be overcome in the shortest possible time through an extensive program of educating the rural population.

e. High cost of farm machinery:

High interest rate and the turnout of a small number of products are responsible for the high cost of machinery produced. Only when the farmers' purchasing power is upped, can the farm machinery manufacturers be willing to lower the price of their products in order to achieve more business turnover.

f. Short of operating fund:

According to a 1959 survey, most of the small factories were short of operation funds and had to pay high interest for loans from private sources, thus making them unable to produce the lower priced products. As most of the machinery parts are made by the small factories, the lowering of machinery prices has to begin from the offering of low-interest loans by the local banks.

g. Sufficient fuel supply for rural areas:

By employing power machines, fuel supply and economy in the use of fuel are problems to be considered. Although Taiwan has its own petroleum refinery to process the crude oil imported from the Middle East, but the problem of how to supply enough fuel of good quality to farmers with a reasonable cost should be studied.

h. Low technical level of manufacturers:

In the early days of industrialization in Taiwan, only "family sized" machine shops were engaged in manufacturing farm implements. Without saying, these small manufacturers had no qualified engineers and also lack of sufficient capital to produce machinery of good quality. According to the report of the 1959 survey, the manufacturers should be helped to solved such manufacturing problems as: gear making; heat treatment; gage-making; and jig and fixture making. Evidently, the small manufacturers can not afford to purchase the necessary machines and equipment for solving the mentioned problems.

The survey indicated that the products of each machine shop were mostly not uniform in quality. This is obviously due to the lack of an effective quality control system and the absence of precision manufacturing and inspection tools. Furthermore, the equipment used in the shops were in most cases obsolete and inefficient. Under this condition, one can not expect to produce things of superior quality, unless technical guidance can be given to elevate the quality and efficiency in the mangement of the machine shops.

2. Mode of owning machinery

a. Mode of owning machinery:

There are different ideas about the mode of owning farm machinery: cooperative ownership and cooperative using, government agency or business owning to render services to farmers, individual owners and independent uses. In considering the points mentioned in Section VI, it is our belief that farm machines had better be owned by individual farmers, as it will put the machine completely at his disposal. Therefore, he will take good care of it; and, besides using machines on his own farm, he may also offer paid service to neighboring farmers. At present, about 95 percent of the 21,153 power tillers in use are owned by individual farmers, and the rest owned by agricultural improvement stations, schools, farmers' association, cooperatives, etc. This is true for the pumps, sprayers, dryers, etc. It proves that Taiwan farmers prefer to own their own machines, if they can afford to pay for them.

b. Size of machinery employed:

In accordance with the mode of individual ownership, a lower priced and small sized farm machine is always in good demand. In the early 1950's, however, the power tiller imported from Japan was too small with only a 2½ hp engine of low working capacity, and it could not be used for deep plowing in land preparation. Only a few were accepted by the farmers in northern Taiwan. Soon the rotary-type tiller with bigger horsepower (Table 2) was gradually used extensively by farmers over the whole island.

As soon as the farmers adopted bigger tiller, no shortage of farm hands will be felt, especially during the harvesting season, the power tiller owners could make use of their spare time to do work for others for additional income. The following table shows the percentages of power tillers for own use and for

other farmers:

Table 4. Power tillers for own use and for other farms

Unit: day

Management area	Total	Work on own farms				Work on other farms				
		Sub-total	Plow-ing	Trans-porting	Pump-ing	Sub-total	Plow-ing	Trans-porting	Pump-ing	Other
Average	78.60	36.91	16.01	11.23	9.67	41.69	22.86	14.87	3.43	0.53
%	100.00	46.96	20.37	14.29	12.30	53.04	29.09	18.92	4.36	0.68
Under 1 ha.	98.40	12.67	3.41	6.40	2.86	85.73	29.24	49.72	6.77	-
%	100.00	12.88	3.47	6.50	2.91	87.12	29.71	50.53	6.88	-
1.0-2.5 ha.	75.60	27.36	9.28	10.64	7.44	48.24	29.12	14.63	3.07	1.42
%	100.00	39.19	12.28	14.07	9.84	63.81	38.52	19.35	4.06	1.88
2.5-5.0 ha.	70.41	37.58	16.49	10.39	10.70	32.83	20.97	9.30	2.66	-
%	100.00	53.37	23.42	14.75	15.20	46.63	29.64	13.21	3.78	-
Over 5 ha.	98.94	66.16	34.57	16.26	15.63	22.48	11.02	7.65	3.81	-
%	100.00	74.72	38.87	18.28	17.57	25.28	12.39	8.60	4.29	-

The same applied to power sprayers and pumps. However, due to the increase in the number of machines, the competition among the machine owners for rendering paid service to others has become stronger, resulting in less profit for them. To reap more profit from the machine, bigger and more efficient machines are needed. On the other hand, there is a strong desire among some farmers to get more income from their machines by saving money for buying medium sized machines for their own use in the future.

5. Technical aspects of manufacturing and marketing

a. Technical cooperation and manufacturing cooperation:

The easiest way to find out what kinds and types of farm machines are suitable for meeting the local needs is to import them for testing. In the early 1950's when power tillers were in great demand in Taiwan, the small manufacturers being inexperienced tried to copy foreign models, but failed to produced serviceable mechines and thus became bankrupt in face of cut-throat competition.

For absorbing the manufaturing techniques and foreign capital of the advanced countries, two separate factories were set up to produce mainly power tillers in Taiwan in 1961. Gradually the two major commandes produced machines of their own making, while some precision parts had to be imported. Now the two companies are producing power tillers in goodly numbers (Table 5) in addition to other small farm machines, thus rendering the import of power tillers unnecessary. On the other hand, the two companies that are presently engaged in producing about the same kind of power machines would lead to competition and constant improvement of the quality of their products, besides strengthening their marketing techniques and services. Anyhow the establishment of two independent companies equipped with technical know-how can be regarded as the forerunner of the farm machinery industry in this country.

In the earlier days of farm machinery extension when the local manufacturers could only produce a small number of machines, the function of the manufacturing factories was centered on parts-finishing and assembly works. It was good to minimize the risk of losing money in the initial investment as such works as casting, forging and pressing were done by other factories, but most of the parts

produced were of inferior quality, thus affecting the quality of finalized machines. Furthermore, the high rate of rejects of their products raised the cost of machine-manufacturing. However, after the establishment of the two large factories, a satellite factory system in which the main factories cooperate with small factories in machine production was adopted. Since the satellite factories are concentrating in the production of certain machine parts, their manufacturing level have been raised to such an extent that their products not only help raise the quality of the machines but also lower the manufacturing cost.

b. Manufacturing and marketing:

At the onset of machinery extension, the manufacturing cost of farm machines was rather high, and some machines actually too high for the individual farmers to own, resulting in very few machines sold and the high rate of interest. The higher the price of a machine the smaller the number of machines sold. So, in order to expand the local market for farm machinery, the price has to be lowered. For the supply of power tillers, it was much in excess of the local demand before 1966. Each of the two major factories could turn out more than 200 power tillers a month, but only an average of less than 80 units sold monthly. Under such circumstances, these factories have to cut down production-- a waste of labor and investment. However, the situation has been getting better since 1967 as shown in Table 5.

In the meantime, manufacturers sold their products through local agent who did business in their respective areas. Most of the agents worked part-time, and left the extension and servicing job to hired technicians. As the sale of a machine was usually transacted through acquaintances, the volume of trade was small. And

the extension work in each area was entirely up to the hired technicians, so no large sale was accomplished.

Table 5. Power tillers produced by the two major farm machinery companies

		China Agricultural Machinery Co. Ltd.		Hsin Taiwan Agricultural Machinery Co. Ltd.	
		(unit)		(unit)	
a. Production capacity(unit/year)		2,400		2,000	
b. Actural production and amount of ousiness done	1968	1,945	NT$150,000,000	1,753	NT$112,000,000
	1967	1,572	132,000,000	1,268	80,000,000
	1966	930	87,000,000	996	60,000,000
	1965	702	60,000,000	876	40,000,000
	1964	490	42,000,000	741	32,000,000
	1963	604	46,000,000	373	24,000,000
	1962	673	36,000,000	618	27,000,000
	1961	229	12,000,000	79	4,000,000
c. Investment in equipment(NT$)		25,000,000		15,000,000	
d. Total capital investment(NT$)		60,000,000		27,000,000	
e. Employment - Managers(incl. clerks)		84		79	
Engineers(incl. technicians)		49		65	
Foremen		6		4	
Operators		210		178	
f. Value of imports		About 30 percent of the parts of power tillers and small diesel engines is imported.			

Benefited from this experience, the manufacturers began to find a better way to market their products. First of all, they increased the number of agents in areas small enough for each agent to operate efficiently, and at the same time the manufacturer himself opened branch offices in some key places to supervice the agents by full-time employees. In the busy farming season, the manufacturer would sent out service cars and additional technicians to help the agents do the extension work more effectively. As each agent needs only fewer technicians and are familiar with the local conditions, better results of extension were thus obtained and consequently the market was expanded.

c. Standardization:

A demand is growing among the local agricultural machinery manufacturers and concerned government agencies to standardize certain farm machine parts and attachments, for there are still many different brands of the same item, which can not be interchanged. This is a task not easily tackled at the present stage, but it is expected that the Chinese Agricultural Mechanization Association which is being organized may take charge of this matter.

4. Research and experiment:

To expedite the extension of mechanized rice farming in Taiwan, emphasis have been placed on research and development of farm machinery by making modifications and improvements on the existing ones and trial making new ones, for the farming conditions in Taiwan are different from other countries. The imported power tillers and their attachments are usually in need of some modifications in order to fully meet the local agricultural demands. When a machine is produced locally, the materials or part of the structural designs are often subject to change.

According to a survey made by PDAF in 1966, part of the power tiller owners still retained some draft animals. In the survey a total of 192 head of draft cattle are still kept by 300 power tiller owners when compared with 401 head before they bought the power tiller. This clearly shows that there are still lack of attachments to replace the animal power completely. Now the two major manufacturers in Taiwan have their own research departments and engineers do the designing and improvement of farm machineries.

Since 1957, all the agricultural research and improvement stations on the island have their farm machinery research personnel try to improve the performance of existing machines and develop new ones. Up to the present, although some progress in the research work has been made by these stations, yet due to a shortage of qualified research engineers, the work progress has been slow. Recently, under the promotion of JCRR, the cooperation between research workers of the government agencies and the local manufacturers has been sped up.

5. Training of farmers and technicians:

Our rice farmers know how to drive and tend water buffaloes, but are mostly ignorant of the use and maintenance of power machines. It is also true for our basic-level agricultural extending personnel. To help them know more about farm machinery, the government agricultural agencies, in collaboration with the agricultural colleges and farmers' associations, have conducted many training classes.

Training of farmers is particulary emphasized in Taiwan. In the early days of farm machinery extension, the small number of power machine owners were taught to operate and care of the machines in their possession with good results.

However, it is impossible to give such intensive training to all of them as the number of farmers using power machines is increasing rapidly and the number of instructors could not be increased proportionally.

Another way is to conduct training classes for the farmers who have owned machines or who wish to own one pretty soon. Since this type of training can only be done at short intervals, farmers may still not have sufficient knowledge to care for their machines. Therefore, some farmers who know power machines well and are willing to offer their services were selected and made "honorary power machine demonstrators". They serve as consultant-advisers to farmers in the selection and use of machines in their own villages. Later on, it was found that the honorary demonstrators gave advices only when they were approached and seldom took initiative in giving instructions.

A third approach is an organized township- or village-level training system. In a town or a village where 15 to 30 farmers have owned power machines, a "mechanized-farming training unit" may be organized. Members of each unit will elect their own leader and dupty leader. Then leaders of all the training units were given technical training for a period of one month. After the training, the members will meet at least once a month in the form of group discussions, lectures by invited specialists, question-and-answer sessions, maintenance and repair practices, field chore competitions, etc. This type of training adopted at the early stage of mechanized farming in Taiwan has met with satisfactory results. In 1960-61, a total of 50 such training units were organized. After the establishment of the two major farm machinery manufacturers in 1961, most of the training of extension and service personnel as well as the farmers has been taken over by the companies themselves.

Another type of training is for the farm machinery workers and trainers. Sixteen and twenty promising young technicians were selected in 1958 and 1967, respectively, from agricultural improvement stations and were given one-year training in the Agricultural Engineering Department of the National Taiwan University. These young men have helped much in conducting various types of farmers training, besides doing research and experiment work on farm machinery in respective stations.

It has also been found that the agricultural administrative officials and extension workers in various government agencies and farmers' associations are also in need of some training on farm machinery and mechanization, so that they can be more efficient to do their part of promoting farm mechanization and supplying the farmers' needs at the beginning of mechanized farming. In the first five years of power tiller extension, altogether 940 agricultural administrative officials and extension workers had attended the training classes lasting from a week to a month, depending on the nature of training.

6. Improving environment for machine extension

a. Providing farm machinery purchase loans:

The cost of farm machinery either imported or made locally are still considered too high for general adoption. To purchase a power tiller with the necessary attachments, the cost will be four or five times that of a buffalo. It is just out of reach of the average small farmer who can not afford to pay in one lump sum. Earlier, a subsidy system was favored for encouraging the farmers to use power machines. However, it is our belief that the use of machines should be a part of the farmers' regular production costs, so they should pay for it.

Therefore, a subsidy is only available for buying new farm machines at the very beginning of extension. The Provincial Food Bureau, the Taiwan Land Bank and the Provincial Cooperative Bank have all established farm machinery purchasing loans. Farmers may borrow the total purchasing cost from the Food Bureau if they agree to repay the loan in terms of paddy rice, or 70 percent (it was raised to 100 percent later on) of the purchasing cost from the two Banks.

The repayment was made in six to ten installments within three to five years, depending on the amount of the loan. And for the payment of the loan on power tillers is to be made in fourteen installments within the course of seven years.

According to a PDAF survey, more than 86 percent of the machine owners had to obtain loans from the agricultural financing agencies. It was suggested that the loan agencies lower the interest rate so as to lighten the burden of the machine owners. Actually, the rate of interest of the loan has been cut down several times in the past few years, i.e. from 0.012 monthly in 1961 to 0.0096 in July, 1967.

b. Rural repair service:

A few years ago many small farm machinery manufacturers in operation in the main townships of Taiwan offered no after-service for their machines produced. So after some of them stopped producing the same type of machine (or when no more such machine was imported) there were many power machines broke down for lack of parts. This created a very poor impression among the farmers who not only lost confidence in the manufacturers but also added to the difficulties of the machine-extension program later on.

It is a felt need that the farm machine repair service should be available and accessible to the power machine users. Throughout Taiwan, there is usually a market center at each township, where the farmers used to visit at least once a week to sell their products and replenish their larder. We have selected twenty of such market centers in 1959 and forty-eight in 1960 at those townships where many farmers are owners of power machines. They were asked to name a machinery repair shop or motorcycle repair shop which was accessible to them as the "appointed repair shop". These selected shops were asked to send at least one of its technicians to the training class conducted jointly by JCRR, TVAF and farmers' associations. These repair shops have carried out their designated mission and served the machine owners quite well by collecting reasonable charges.

In 1961 when the two major agricultural machinery companies were set up and initiated the island-wide after service system in addition to several service cars regularly touring the island, it amply demonstrates that the manufacturers are making earnest efforts to educate their sales agents and users on how to use their machines properly in order to attract more users.

As a new attempt to expedite the farm mechanization program in Taiwan, a network of twonship farm mechanization promotion centers in the principal townships was established by the government and concerned farmers' associations in 1966. Through the network, fuller utilization of the existing farm machines and larger-scale extension of new ones can be realized. Each center is provided with a workshop equipped with necessary machines, tools and spare machine parts which are supplied on a cost basis by the farm machinery manufacturers for making repairs of farm machines, thus a province-wide maintenance and repair-service system is established.

Through the above-mentioned centers an extensive training program will enable the farmers to use their farm machines more efficiently and effectively. Up to the present, ten centers have been established at ten principal townships to be responsible for the extension and repair of machines and training of both the present and future machine users.

c. Fuel supply in rural area:

The fuel for power machines can be purchased from fuel stores in all the principal townships, but they are usually not clean enough and sold at a stiff price, thus affecting the service life of machines, especially the diesel engines. It is also not convenient for a farmer to purchase quality fuel from distant downtown gas stations. To help the farmers to get quality fuel, the China Petroleum Corporation under JCRR assistance has established a number of small fuel stations in suitably located townships, but the number of fuel stations can only be increased gradually to cover all the townships. Though some township farmers' associations bought fuel in bulk to meet the need of the farmers, many farmers still prefer to purchase fuel on credit from the small fuel stores, thus losing in the end. How to supply cheap, clean fuel in sufficient quantities is indeed one of the important problems to be solved before the program of farm mechanization can be stepped up.

7. Power machine test:

To make sure that any power tiller bought by individual farmers is of good quality, our government makes it a rule that any new model of power tillers should be thoroughly inspected before it is put on the market. The government then drew up a power tiller testing standard, and meantime strengthened the

testing facilities in the Colledge of Agriculture, National Taiwan University, for conducting the inspection work. The manufacturers were required to sent in samples of new models for inspection. But this practice was only convenient for the big factories whose products were of uniform quality, whereas the samples from small factories might be different from similar products they produced. Thus, in order to guarantee uniform quality of the products manufactured by the small factories, all products instead of mere samples are to be inspected. This kind of inspection work has also been extended to the test of power sprayers and mist-blowers later on.

IV. Significance of Mechanized Rice Farming

A. More income to rice farmers

1. Rice yield increased:

Mechanized farming is aimed at increasing land productivity and saving a part of farm labor for better utilization. With a power tiller, a farmer can prepare his field on time and do it better than the manual labor. To prepare one hectare of paddy field ordinarily takes 7 - 10 days for a man with the help of a buffalo, but it now requires only 2 - 3 days with a power tiller, thereby making timely sowing and transplanting of rice possible. Based on experience if rice is transplanted within a week of the most favorable period, the yield may increase by 2 - 5 percent, for it will provide a better condition for the rice-root systems to develop, make full use of a period of fine weather, and expand the limit of the "Law of Diminishing Return" in regard to the application of fertilizer. Besides, the deep plowing achieved by power tillers make the paddy

fields hold more water as well as more fertiliser.

According to a 1966 survey on the results of power tiller utilization in Taiwan conducted by PDAF, the owners of power tillers are enjoying higher average yields than those who depend on manual labor (Table 6)

Table 6. Average per hectare yields of the first and second rice crops

	Before using power tiller (kg)	After using power tiller (kg)	Percentage increase (%)
First crop	3,957	4,443	12.28
Second crop	3,544	3,846	8.52

It has been an established fact that through using power sprayer and other power machines, the unit yield of rice will show a substantial increase. According to a three-year (1965-67) experiment conducted by PDAF Agricultural Improvement Stations in the Taipei, Taichung and Tainan areas on the rice yields of power machine owners and non-power machine owners, the average unit yield of the former was much higher than that of the latter (Table 7).

Table 7. Comparison of average rice yields between power machine owners and non-power machine owners

Unit: kg/ha

		Power machine owner	Non-power machine owner
Taipei (north)	First crop	3,358.80	3,173.31
	Second crop	2,978.81	2,737.46
Taichung (central)	First crop	6,062.91	5,525.73
	Second crop	4,759.96	4,295.83

Table 7. (cont'd)

Unit: kg/ha

		Power machine owner	Non-power machine owner
Tainan (south)	First crop	6,465.61	5,546.15
	Second crop	5,664.28	5,179.65

It is expected that when farmers have adopted rice transplanters, the rice yield would be still higher. Though higher yield is closely associated with mechanized farming, it does not necessarily mean that machine alone can increase the unit yield. After all, high yield to a large extent is the result of high capitalization which usually involves mechanization of cultural practices.

2. Farmers' income raised:

According to a study, rice farmers who own one hectare of land or less, their gross income used to be around NT$21,000 per annum. After they have adopted the power tiller, however, their annual income would average NT$32,350, i.e. the 1.0 - 2.5 hectare group from NT$55,960 to NT$61,850, and the 2.5 - 5.0 hectare group from NT$86,910 to NT$94,200. By using power farm implements, the rice farmers can, therefore, enjoy an additional income of about 11.5 percent.

The JDAF three-year study at three locations also reveals the fact that the income of machine-owners is higher than that of the non-machine owners, as shown in Table 8.

B. Higher living standards

1. Farmers' living conditions improved:

The rice farmers after acquiring power machines need less time to get the same piece of farm work done, so they have time to do work for others in

order to get some additonal income, or they may use the time saved to raise more livestock or engage in other sideline productions.

Table 8. Average income from one hectare of rice farm per annum (1965-67)

Unit: NT$

District	Power machine owner	Non-power machine owner
Taipei	40,106.30	31,531.30
Taichung	66,744.30	57,748.10
Tainan	59,858.90	48,501.30

The farmers who use bufalloes usually get up and start work very early in the morning and work till late in the evening. The working hour is so arranged as to suit only the buffaloes but not the farmers. By using power machines, they can work at any time they choose and do it better and faster. In the evening a farmer may have time to enjoy themselves by hooking a trailer to his power tiller to visit friends or relatives or even go to a show. Another thing worth mentioning is that the school-age childen (now nine-year compulsory schooling) do not have to watch and care for buffaloes after school, but to have more time to study their lessons.

2. Distances between rural and urban districts shortened:

A buffalo can travel at a speed of about 2-3 kilometers an hour. A farmer usually sends his farm products to the market by a cattle-drawn cart no further than 4-5 kilometers away. Some of them may travel as far as 10 kilometers, but that is about the limit they can go, because it would take them a whole day to make a round trip. On the other hand, the speed of a power tiller with a trailer

is more than 15 kilometers per hour. So a farmer can make two or three round trips to the market in a single morning, or go to a distant town 40 or 50 kilometers away and be back before dark. This makes a big difference to the farmer, as the power machine can greatly extend the radius of his business activities. He may sell his farm products in a better priced market, and raise perishable vegetables and fruits of high market value without suffering a loss from delay, simply because he has a power machine at his disposal.

C. Affect of farm mechanization on rural welfare

1. Attracting more educated youth to rural areas:

It is usually the case in China or elsewhere that young educated youth from the country are reluctant to go back to their farms. They prefer to find jobs in the cities or industrial districts. To stem the tide, many fathers buy power machines for their sons, especially for the educated ones, to operate in their farms, for they hate to walk behind a buffalo and toil all day long with their hands. With a power machine, a young farmer can do better work in the field and still have time to enjoy themselves. The mechanization of rice farming can, therefore, keep a number of capable, educated young men satisfied with their life in the villages, thus contributing to the further improvement of agriculture.

2. Stimulating the growth of rural industry:

Farmers with power machines at their disposal can do a lot of extra work for additional income. For instance, rice straws can be made into straw ropes or straw bags by a pedal-operated machine or straw looms in small quantities. Now the farmers with power machines can do all the propelling with the machine. The uniform speed and the higher efficiency of the power-propelled machines can

make straw ropes better and cheaper. A new rural industry is thus developed. Furthermore, a number of agricultural processing work, such as the refining of mushrooms and asparagus, can also be rural industries, because they can be produced at lower cost and close to the sources of supplies.

3. Promoting some commercialized production:

In the irrigated fields there grow two rice crops a year, or possibly three rice crops a year, in addition to many other crops added to the crop rotation system. To this intensive farming the power machine has contributed a lion's share, because they can do the field operations much quicker and better than the conventional way. Aside from rice, other crops raised are rape-seed, soybean, flax, jute, sweet melon, pickling melon, vegetables, tabacco, barley, wheat, sweet potato, etc. Since most of these crops are not for local consumption, they have to be disposed of. Power machines can transport these crops to the distant markets for greater profit. Commercialized production of other crops interplanted in the rice field has thus been sped up by the utilization of farm machinery in Taiwan.

D. Farm mechanization and the farming system

1. Helpful to the cropping system:

Farming practices in Taiwan are intensive as compared with most of other countries. After the introduction of power machines, the cropping system of Taiwan tends to become more intensive. For example, in the central part of Taiwan, the cropping system is more developed because they have adecuate irrigation facilities. Before harvesting of the first rice crop, melons, pickling cucumbers, etc. are planted in the same field. But after harvesting of the

summer crop, the land has to be prepared promptly for transplanting the second rice crop. Again, in the fall before harvesting the second rice crop, tabacco and sweet potato are planted in between rice rows, or wheat, flax, etc. will be planted right after the rice harvest. It leaves very little time for a farmer to prepare his field. If a power machine is used, the paddy fields can be prepared within a very short time. So, the adoption of farm machines has made the intensive cropping system more practicable. No wonder the number of power machines in this area ranks first in Taiwan.

2. Support to the rotational intermittent irrigation system:

According to the results of a series of experiments on rotational intermittent irrigation conducted in Taiwan, this practice not only can save 26 percent of the water, but also raise the rice yield to a certain extent, because the soil is better aerated and the temperature better regulated than being constantly under water. Since more water is needed for irrigating more lands and this irrigation method makes fullest use of water, it means that the same amount of water can be used to irrigate more land. Work has now started to modify the existing irrigation canals for the adoption of the rotational irrigation system.

Under the irrigation system, the farmer can easily make out that he has only to prepare the paddy field when it is in need of irrigation water. A power tiller can get the job done within the time limit, but not a buffalo. Since the initiation of the new rotational irrigation, farmers have shown more interest in acquiring machines.

V. Conclusion

Under the farm mechanization program initiated by JCRR 15 years ago, special emphasis has been placed on the production of agricultural machines, particularly for the paddy field which accounts for more than half of the cultivated land in Taiwan. The mechanization of rice farming started with the adoption of power tillers and attachments and followed by the gradual adoption of other farm machines, such as power sprayer, grain dryer, rice transplanter, etc.

Since the advent of power tillers the traditional processes of farming on the island has undergone a big change. Rice culture in Taiwan is being modernized gradually. Yet, it is still lagging behind the developed countries in terms of mechanized farming, because there is still room for improving such farming operations as transplanting, weeding, fertilizing and harvesting.

It is considered a very difficult task to mechanize small farms in Taiwan. Nevertheless, government authorities as well as the agricultural leaders have mapped out an overall plan for the full mechanization of rice culture. In the meantime, the mechanical engineering circles are making strenuous efforts to develop a number of farm machines which will enhance the land productivity. For, agriculture in Taiwan has been advanced to such extent that farm mechanization is boun to gain in popularity in the years to come as it can replace part of human labor needed in the booming industry.

Topographically, Taiwan is located between the temperate and tropical zones, whose farming methods and the processes of farm mechanization are applicable to other countries in Southeast Asia and most parts of Africa. Already the technical know-how we acquired in these years has been extended to many Asian and African

countries for enriching their food supplies, particularly rice.

In considering the introduction of mechanized rice farming in any area, it is advisable to pay due attention to the following conditions:

1. Machines must be adapted to the local conditions,
2. Machine operators should have mechanical know-how,
3. Service centers are to be provided,
4. Power and machinery are most beneficial where power and speed are needed for cultivating the unused land,
5. Improper or poorly adapted machines tend to increase production costs,
6. Farm mechanization is handicapped by the low purchasing power of the general farm population, poor handling and maintenance of machines, small irregular fields and surplus labor.

REFERENCES

1. Peter Kung (1956): Rice culture in Taiwan, China. JCRR Plant Industry Series No. 9

2. H. T. Chang (1956): Natural environment and crop distribution in Taiwan. JCRR Plant Industry Series No. 13

3. F. C. Ma (1957): On the agricultural mechanization in Taiwan. JCRR Plant Industry Series No. 14

4. F. C. Ma (1959): Promotion of agricultural mechanization in Taiwan. Chinese Society of Agricultural Engineering, Bulletin No. 17

5. JCRR (1959): Rice improvement in Taiwan. JCRR Plant Industry Series No. 15

6. T. Liang and T. S. Peng (1960): A study on the labor-hour requirement per unit farming operation of eleven crops in Taiwan

7. JCRR (1960): A survey on power tiller manufacture in Taiwan. JCRR Plant Industry Series No. 18

8. C. S. Chang (1961): Taiwan University power tiller test, report on the preliminary test results. Power Tiller Testing Laboratory, National Taiwan University

9. A. D. Faunce (1961): Some considerations for the introduction of agricultural machinery in newly developing countries. Paper presented at the International Technical Congress of Agricultural Machinery, Paris.

10. JCRR (1962): A summary report on economic analysis of farm mechanization in Taiwan. Rural Economic Division, JCRR

11. JCRR (1963): Current report on rice production. JCRR PTD-R-63-4

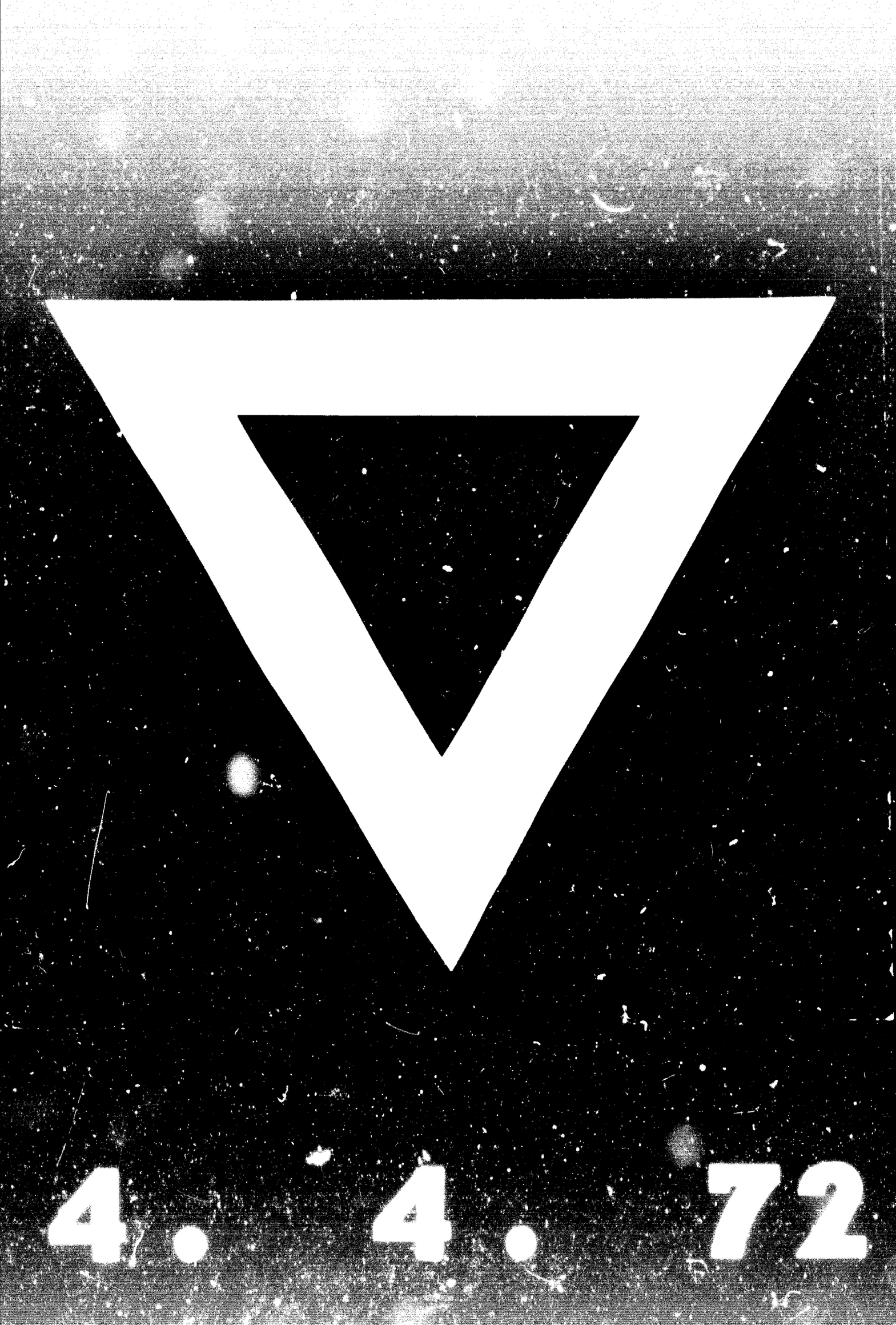
12. PDAF (1966): Report on the survey of power tiller used in Taiwan Province

13. S. K. Chang and P. C. Lin (1967): Rice cultural practices in Taiwan

14. T. S. Peng (1967): Development of the power tiller and farm implements manufacturing industry in Taiwan. JCRR EM-C-319

15. T. S. Peng (1968): The development of rice transplanter and its effect on rice farming in Taiwan. Journal of the Chinese Society of Agricultural Engineering, Vol. 14, No. 3,4

16. PDAF (1969): Studies on the influence of farm mechanization on Taiwan's agricultural productivity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