CHINESE-AMERICAN

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Plant Industry Series No. 14

ON THE AGRICULTURAL MECHANIZATION IN TAIWAN

By

Fengchow C. Ma

TAIPEI, TAIWAN, CHINA

SEPTEMBER, 1957

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Under the auspices of

Dr. H. T. Chang, Chief

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(English Text by Nancy Tsai)

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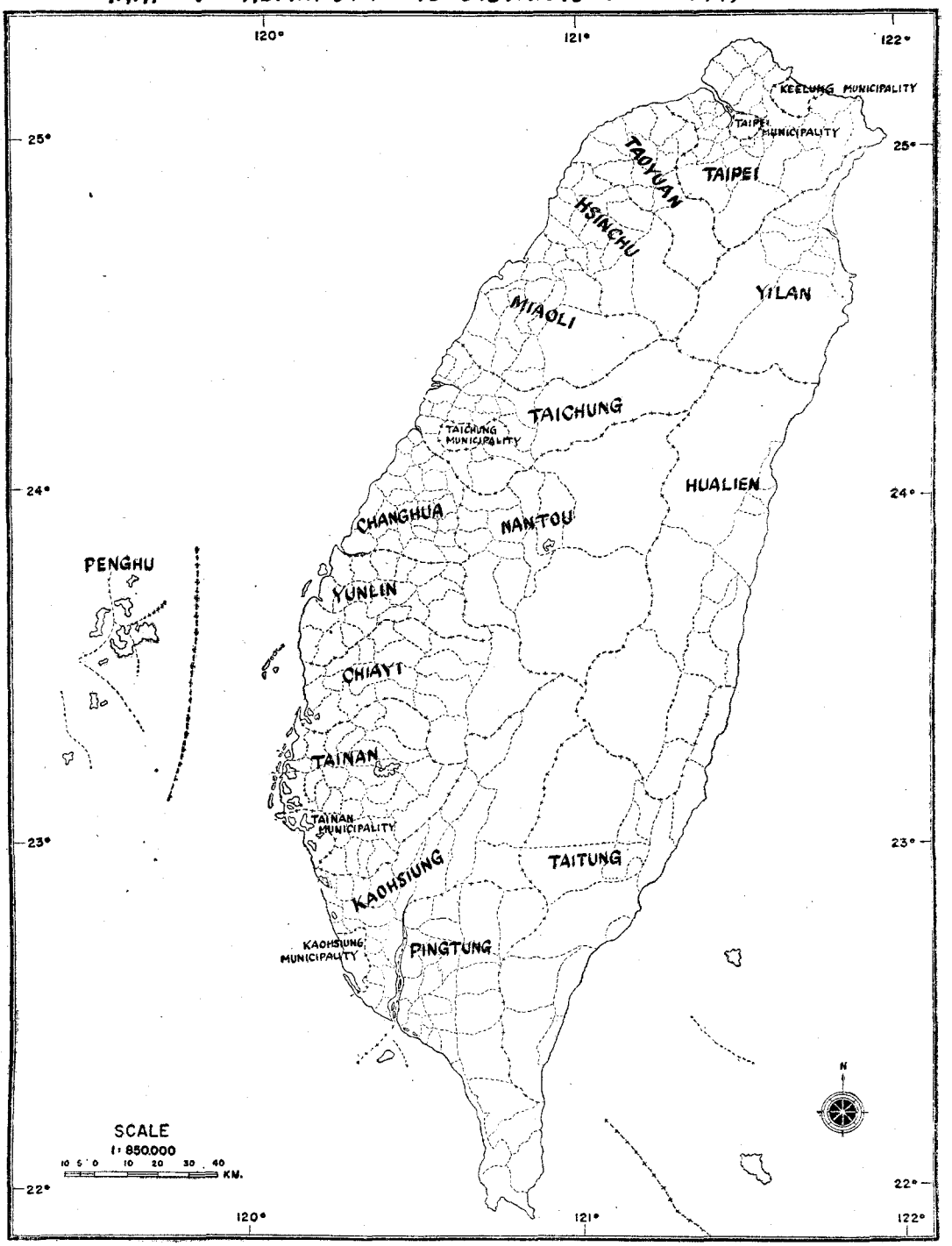
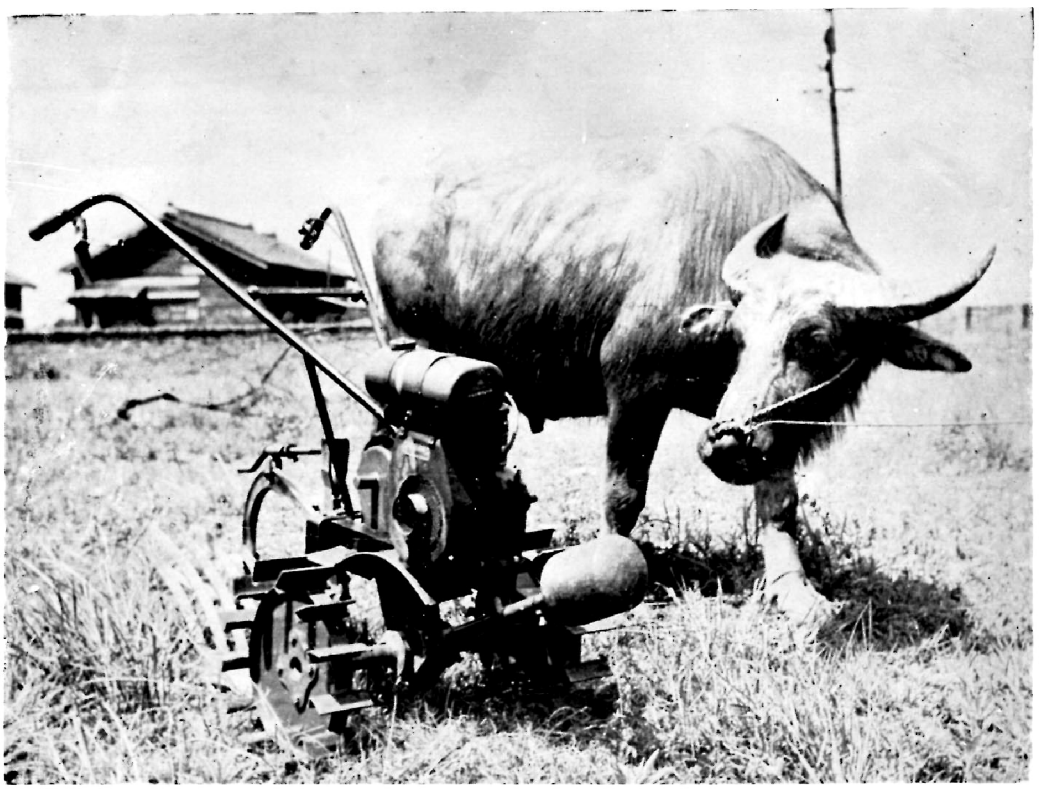


PART ONE

CAN THE AGRICULTURE IN TAIWAN BE MECHANIZED

April, 1956



THE OLD MEETS THE NEW

FOREWORD

Much has been accomplished in the past in agricultural improvement in Taiwan. Continued agricultural production increase is necessary in the days ahead to meet the needs of the increasing population and for the maintenance of economic stability of this Island. The ways for further increasing agricultural production may be (1) the proper utilization of the slope land, (2) development of tidal land and other land that have not been fully utilized to date (including weather-depending fields, saline fields, and gravelly land), and (3) raising the efficiency of agricultural production and putting the farmland to even higher intensive utilization.

Mechanization of farming operations as discussed in this article is one of the methods to increase the efficiency of agricultural production. To mechanize agriculture in a country with a large population and insufficient farmland, there should be actual need for such undertaking on one hand and also adequate standards of farmers' knowledge and local industrial manufacturing capability on the other. As a consequence of the rural reconstruction work carried out after the restoration of Taiwan and of the rapid industrial development in recent years, we believe that the agricultural industry in Taiwan is now on the threshold of mechanization.

Though man power in Taiwan is considered abundant, but according to the estimation of the livestock specialists the number of draft cattle is short by about 100,000 heads. With the the gradual expansion of farmland, feeding cattle on the plain will become more and more difficult. Therefore mechanization of agriculture to a suitable extent will not only make up for the shortage of working cattle but also enable the timely undertaking of farming chores necessitated by the extremely busy farming schedule of Taiwan. In view of these facts, it is our opinion that the need for agricultural mechanization has begun to be felt in Taiwan. It is true that the knowledge of the farmers, the physical limit of the average farms and the standards of the industries in Taiwan are such that they do not yet warrant the use of large farm machineries, as are being used in the U.S.A. However, some of the smaller power tillers used by the U.S. and Japan after the last War can very well be adopted in Taiwan. Except perhaps for the engines, part or whole of these tillers can very possibly be made in Taiwan in the future. These tillers only require 3-5 h.p., are relatively simple in structure and in size (even smaller than a buffalo), and cost only two to three times the price of a buffalo. They can be used in all

the fields that draft cattle can work and plow deeper and work faster than the cattle. Moreover, after using, they can be stored safely and need no more feeding or caring as are necessary for draft cattle.

The following article expounds the theme of mechanized farming in Taiwan by using primarily small power tillers. For compatriots who have been skeptical about the feasibility of mechanized farming in our Country, this article may provide a new outlook. It is our belief that if provision of necessary fuels can be assured by the authorities, mechanization of agriculture in Taiwan may become feasible before long. The use of small power tillers may prove to be an epochal event in the agricultural history of China and we look with optimistic anticipation into the future.

H. T. Chang, Chief
Plant Industry Division
JCRR

April, 1956

On the Agricultural Mechanization in Taiwan

Part One

Can the Agriculture in Taiwan be Mechanized

I. Introduction

Tremendous improvements have been made in agriculture in Taiwan in recent years. Not only is the annual agricultural output sufficient to meet the domestic need but there are also surpluses for export. It is essential hereafter to further increase the efficiency and lower the costs of agricultural production not only for providing more food for the people but also for earning more foreign exchange. Conforming with the Chinese philosophy that "better job can only be done with better equipment", much emphasis is now laid on the improvement of farm machineries for further promotion of agricultural production. Farmers are in increasing need of improved farm tools; newspapers and magazines carry in detail news in this field. Diverse opinions have been expressed on this subject. As a professional agricultural engineer, I would like to express my personal opinion on this subject for the reference of those concerned.

II. Pros and Cons of Agricultural Mechanization in Taiwan

In general, agricultural mechanization can be easily carried out in areas of larger farms. The considerably successful mechanization of the large plantations owned by the Taiwan Sugar Corporation and the Taiwan Pineapple Corporation has set the example for mechanization of other larger farms. The mechanization of small farms, however, was only brought up in recent years. The outlooks on mechanization of the average sized privately owned farms in Taiwan are divided into the over-optimistic and the over-pessimistic:

A. The over-pessimistic outlook:

1. As full employment is not attained due to over-population, it is not wise here and now to substitute man power with machines.

2. As most farms are small and scattered, the use of machines is difficult. Therefore agricultural mechanization is as impractical as culture of

big fish in a shallow pond.

3. Farm machineries, fuel, etc., all have to be imported. It is not economical to spend more foreign exchange at this time of national financial stringency.

B. The over-optimistic outlook:

1. Agricultural mechanization is a world-wide trend of agricultural improvement. As it has been implemented in other countries, so it will be carried out in China. Although farm machineries can not be manufactured in China yet, we should not make it a foregone conclusion that we should give up agricultural mechanization. We have not been able to manufacture automobiles, locomotives, airplanes in China either, but we have been using them for years. Agricultural machinery is a necessary investment and it should be accepted by people in the agricultural field as automobiles, locomotives, and airplanes in the field of communication. What we should do is to meet the new trend head-on instead of confining our activities in set circles.

2. The crux of the matter of agricultural mechanization lies in the provision of farm machineries. The machinery manufacturing industries of Taiwan could produce machines that are more elaborate than farm machineries. It is not technically difficult to produce simple farm machineries if markets for such products exist. Adequate supply of farm machineries will no doubt stimulate and help farm mechanization. We should not confine ourselves to the traditions of the old rural society and refrain from doing what we should.

III. Our Points of View

While we are willing to listen to the pros and cons of agricultural mechanization, as both sides are sincerely interested in the subject, we wish to allay some skepticisms regarding the practicability of agricultural mechanization in Taiwan.

A. Abundant manpower, insufficient draft cattle.

The matter of population, looked at from the general perspective of agricultural management, is a part of the question of power supply, which, although a very important part, does not however constitute the entire requirement. In some work, animal power is necessary and can not be substituted by man power. This is true in the rural areas of Taiwan, where there is abundant man power, but insufficient animal power, and the animal power needed can not be replaced with man power. In between two crops, because of insuf-

ficient supply of power, the land for the next crop is as usual very poorly prepared. This will affect the yield. According to the 1954 Agricultural Yearbook published by PDAF (Taiwan Provincial Department of Agriculture and Forestry), the number of cattle in Taiwan was 390,000 heads while the area of cropped land was 872,000 hectares, averaging about 2.24 ha. of crop land to one cattle. Supposing that two thirds of the total number of cattle were of working age, then each head of working-age cattle had to work over 3.36 hectares, and in some areas more than 4.5 hectares. (See table below)

Duty Area for Cattle in Taiwan

Hsien/city	Cropped land (ha.)	No. of cattle (head)	Average duty area for each cattle (ha.)	Average duty area for each wroking-age cattle (ha.)
Taipei Hsien	53,573	16,970	3.156	4.736
Ilan Hsien	28,067	9,872	2.843	4.265
Taoyuan Hsien	58,596	20,568	2.848	4.273
Hsinchu Hsien	45,764	18,019	2.539	3.810
Miaoli Hsien	46,793	17,645	2.651	3.978
Taichung Hsien	48,279	27,776	2.119	3.180
Changhwa Hsien	74,927	24,235	3.092	4.637
Nantou Hsien	43,315	19,388	2.234	3.351
Yunlin Hsien	85,452	33,344	2.562	3.844
Chiayi Hsien	71,988	26,570	2.709	4.064
Tainan Hsien	97,929	44,021	2.224	3.337
Kaohsiung Hsien	51,994	29,320	1.773	2.660
Pingtung Hsien	76,559	47,064	1.627	2.440
Taitung Hsien	21,365	19,289	1.107	1.657
Hwalien Hsien	29,008	21,067	1.376	2.065
Penghu Hsien	7,522	4,071	2.093	2.772
Taipei City	2,367	1,837	1.288	1.932
Keelung City	2,279	628	3.628	5.439
Taichung City	9,656	4,098	2.356	3.534
Tainan City	7,554	4,318	1.749	2.670
Kaohsiung City	5,685	3,211	1.770	2.655
Yangmingshan Adm.	4,568	1,833	2.492	3.738
Total and grand average:	872,738	390,144	2.236	3.355

The excessive workload imposed on the cattle resulted in crude land pre-

paration, delay in planting and harvesting, and failure to attain the highest production potential of crop land, not to mention the injury to the health and the reduction of servicing years of the cattle. In the agricultural portion of the Four-Year Plan, animal husbandry authority has estimated that at least 500,000 heads of draft cattle are needed for Taiwan. In other words, each cattle should only have to work over 1.5 hectares, or each cattle of working age should only have to work over 2.5 hectares of crop land.

Let us now discuss the problem of increasing draft cattle. To increase cattle population, we must first solve the problem of feed supply. Roughage should constitute 80% of the total quantity of cattle feeds. According to Professor T. F. Chang of National Taiwan University, a cattle needs 36 kg. of roughage a day, i.e. 13,140 kg. a year. The statistical data for Taitung Hsien in 1936 gave the output of roughage as 4.14 kg. per tsubu (1 tsubo=3.31 square meters) of good grassland, in other words, each hectare of grassland could merely supply roughage for one cattle each year. The annual output of roughage is 2.4 kg. per tsubo on land such as woodland, land along ponds and farm paths, etc. That is the roughage for each cattle annually has to be supplied by 1.8 hectares of any such land. Rice straw, sugarcane tops, sweet potato vines, etc. are mostly used by farmers as hog feed or for making compost, and therefore can not be used entirely as cattle feed. Even if these latters can supply 1/5 of the roughage needed for a cattle, more have to be obtained from either 0.8 hectare of good grassland, or from 1.4 hectares of woodland, land along ponds, farm paths, etc. for each head of cattle.

From the above table, we can also see that in the Taipei area the workload per head of cattle ranks the highest, and in the Taitung area the lowest. This is attributable to the fact that, in northern Taiwan, the well-developed rural areas can spare very small area of land to produce roughage for cattle. This fact is recognized by all who often go to the countryside. Under these circumstances, it is doubtful whether we have 80,000 hectares of land to produce the needed roughage for 100,000 additional heads of cattle.

PDAF and JCRR have proceeded to investigate the possibility of more grassland in the mountain areas, with the aim of raising more cattle. This serves to show the recognition of the shortage of animal power in Taiwan. In the United States, in the recent fifty years since the first tractor was made in 1902, farm machineries have taken over most of the work from draft animals. About 70 million acres of land that used to produce feedstuff for the draft an-

imals are now used to produce food and clothing materials for human use. In Japan, whose population is proportionately bigger than ours in comparison with cultivated land (especially after World War II, when most overseas Japanese were repatriated), averaging 0.84 ha. of farmland per household, as against 1.15 hectares per households in Taiwan, more farm households have been using power tillers since the close of the Second World War. At the end of 1953, 113,000 households were using farm machinery and more were inclined to follow suit. One of the reasons for the Japanese in doing this, is that they want to use machineries to replace cattle in order to increase the area of land for producing food and clothing supplies. In the long run, therefore, with the increase in population there will be growing need for more farmland, and consequently, there will be less chance for expansion of grassland to raise more draft cattle. Use of agricultural machineries in Taiwan in this stage will make up the animal power shortage and, at the same time, will be one step forward toward the long range goal of intensive utilization of farmland.

B. Small power tillers can be maneuvered handily in small farms

The point most strongly stressed by the pessimistic school is the fact that farms are small and scattered. Luckily, the advance in the science of agricultural machinery has made it possible to apply the small sized farm machineries to cultivate the small size farms.

To go back to the beginning of power farm machinery, the power furnished to and the weight build on the farm tractors have been on a gradually increasing scale in the first three decades immediately following the first use of tractors. These increases were made to increase the friction or traction between the wheels of the tractor and the earth, in other words, to increase the work efficiency of the tractor. Later, the agricultural engineers found through research that, if the weight of the tractor could be well balanced, the traction could be considerably increased even if the tractor is lighter in weight. This discovery accounts for the gradual development of smaller tractors for smaller farms in the past two decades.

The wide spreading of "gentleman farming" in England, and the victory gardens in the United States during the last World War greatly inspired the development of garden tractors of various size. The garden tractor is a small tractor operated by a man on foot behind it. The tractor can only be mounted with one 10" plow. It can tow any kind of farm implements just like the larger tractors; only these implements are smaller in size as well as in work-

ing capacity.

Since the theory of rotary cultivation was expounded, the rotary tiller came into being. It uses a set of suitably curved steel blades called tilling tines (or whatever it's commercial name may be) to stir and loosen the soils and produce good tilth. It does not leave a hard pan in the field. Furthermore, it does not require too much power to operate. It was quickly adopted by some farmers (mostly small vegetable garden owners in western countries). As there is as yet no common name for the two kinds of power cultivating machineries, we shall call them here "power tiller". They are designed exclusively for dry fields.

Power tillers for paddy fields were first developed in Japan and England some twenty years ago. Because the Japanese consider paddy rice as their major crop, and there are many places growing rice in the British colonies, the manufacturers tried to convert the upland power tillers for paddy fields. However, the trial use of the converted tillers has not been very successful in Japan as well as in Southeast Asian countries. After World War II, many machinery manufactories in Japan originally engaged in war supplies and weapons were converted into factories for machines for peace use. Farm machineries have therefore received attention from the machinery manufacturing industry. As results of the free competition of the farm machinery manufactories, more power tillers were produced and the produces were better and better. The typical Japan-made paddy field power tiller uses Japanese type kerosene or diesel engines and adopts as the main tool the rotary tiller. Because the engine used is of stationary type, it can be dismounted for other uses for instance, pumping water. The most serious shortcoming of this kind of tiller is its difficult maneuver due to its excessive weight——mostly over 200 kg. The Japanese manufacturers have been seeking improvements. One manufacturer cooperated with an American firm, the Merry Mfg. Company, to modify the Merry Tiller and make it suitable to farming environments of Japan. The main points of improvement are the lowering of the handles to suit the height of the Orientals and to elongate the handles so that, when rotary tilling equipment are removed and wheels are attached, there will be enough room between the operator and the wheels to accommodate plow, harrow, cultivator, weeding machine, and other working tools. Another point which is more important is that by changing to different kind of wheels, the tiller can be used both in paddy fields and in upland fields. Its engine can also be used for spraying, for trailers, or even for washing machines. Thus this power tiller will not only

combine the garden tractor and the rotary tiller in one but will also serve as a small power plant to do other works on the farm. Its servicing hours will be much longer in a year. This modified Merry Tiller still uses the U. S. made four-stroke cycle air-cooling gasoline engine; therefore it weighs only about 60 kg. which is much lighter compared to the typical Japanese type power tillers. There will be no difficulty to carry the tiller over the paths of the field however narrow they may be as it can be lifted by any farmer. Although the engine of this kind of tiller has only 2.5 rated HP, in actual use, it can produce about 1.3 drawbar HP. Compared to the low mechanical efficiency produced from the engines mounted on Japanese type power tillers, it will not have too little working power as its size and weight may suggest. The Japanese call this type of power tillers the extra small power tillers. About five or six manufacturers in Japan are turning out small power tillers similar to the modified Merry Tiller. These newly modified small power tillers are light and small, less than 1/3 the volume of a water buffalo, and can be easily maneuvered on any small piece of land in the farm. Computing the area of farmland per household in Taiwan, the drawbar HP of the tiller and the power of a draft cattle, we feel that one such "Merry Tiller" should be able to serve two average farm households in Taiwan. We are glad to say that this small power tiller has solved our problem on mechanization of our average farms. Fifty thousand such power tillers could amply make up the 100,000 heads of cattle we are now short of.

C. Exploring the supply of fuel

Whenever the word fuel is mentioned, people always think that it is economical to use diesel, or at least kerosene, for farm tillers. This is true when the supply is abundant or when only few people are going to use the power tillers. If we are to put 50,000 power tillers to use in Taiwan, we have to consider the problem of supply of fuel from an overall angle. Judging from the present situation of fuel supply, gasoline is easier to get than either diesel or kerosene. We estimate that for the small power tiller with engine of 2.5 rated HP, working ten hours a day, two gallons of gasoline are needed. Assuming that each small power tiller has an average of 1,000 working hours a year, 200 gallons of gasoline will be needed; for 50,000 tillers, therefore, 10 million gallons (about 37,850 kilo liters) of gasoline are needed annually. The latter figure will be 23.6% of the present annual output of the China Petroleum Corporation (assuming the annual output of gasoline of the said Corporation is

160,000 kilo liters). However, the 50,000 tillers will not be put to use at once. With the gradual increase in the number of power tillers in the farm, a matched growing system on supply of gasoline to the rural area, it seems to us, should not be of much difficulty, as it may take 7-8 years to reach the goal of 50,000 power tillers in the farms.

What we are most concerned with and sincerely hope for is the acceptance of the idea on using power machineries in farming as a trend of not only agricultural but also social improvement which will be beneficial to both the rural population and the national economical developments. It is our opinion that the government should make available sufficient gasoline for the use of the tillers and should not obstruct this epochal improvement with the sole consideration of possible expenditure of foreign exchange.

On the other hand, we should also explore the possibility of finding substitutes for gasoline. For instance, if the liquefied petroleum gas is available in small accessible containers and has light weight pressure regulators and heat exchangers, it would be good fuel for the gasoline engine of the small power tillers. We understand that experiments on production of LPG is now being carried out energetically by the China Petroleum Corporation. It is also possible to use alcohol in gasoline engines (in this case the carburetor should be made one size larger). The Taiwan Sugar Corporation is producing about 20,000 kilo liters of alcohol a year. Aside from that consumed by the Corporation's tractors, there should be ample excess for the farmers' use. Therefore we should at present encourage the use of gasoline engine powered tillers on the one hand and find substitute for gasoline on the other.

D. Selecting farm machineries for Taiwan farming conditions

The foregoing discussions may make the readers over-optimistic about agricultural mechanization in Taiwan. However, more facts have to be considered:

1. Granting the fact that farm mechanization is a scientific improvement and a natural trend in agricultural production, it is not as easy as buying a new outfit and putting it on. Farm machineries have to be adapted to the farm conditions that they work on and there exist differences from one locality to another both in soil, climate and social and economic environments. To attain complete fitness, gradual improvement on the imported farm machineries is deemed necessary. The Taiwan Sugar Corporation, which has been using farm machineries for many years, has now come to know that the imported

farm machineries do not fulfill the special needs of their plantations, and is now proceeding gradually in devising and converting farm machineries for their own needs to enhance the efficiency of production. To use these small power tillers in China, we cannot avoid exerting similar efforts.

2. The large scale farm machineries used by the Taiwan Sugar Corporation has given the farmers the impression that all the farm machineries used should prepare the land to a depth more than 10 inches or something like that. If they measure small power tillers by this scale and hope to get the same amount of work done as the large tractors, they may be disappointed and tend to give up.

Small power tillers can only be used in fields that are already under cultivation and of good tilth. They are not suitable for land reclamation or work on special hard soils. In cultivated fields, the tillers are much more effective than the draft cattle. Therefore when we want to start farm mechanization, we should first find out the capability of the machines that will be introduced to farmers, and secondly, understand fully the psychological reactions of the farmers. Only after these are done and with effective persuasion of the farmers and sufficient tangible help to solve their problems can we carry out this long range program of agricultural mechanization.

The farmers of Taiwan are accustomed to draft cattle and they know how to select draft cattle. As power tillers are totally new to them, they would hardly know sound selections. This is not only true of the Chinese farmers, but of the farmers in other countries as well. For instance, the farmers in the United States have to select their tractors with Nebraska test as reference, and the manufacturers are not allowed to make advertisements in exaggerated terms away from such test. In Japan, the Ministry of Agriculture and Forestry conducts official farm machinery test and publishes the results and lists of approved products from time to time. The personnel in charge of agricultural machineries in the prefectural government will then choose from these listed articles for further test to find the ones most suitable to its specific territory and announce the results for reference of the farmers. Chinese farmers are not acquainted with the power tillers and the government has not conducted any of such tests on farm machineries yet. So when we recommend tillers to the farmers, we have to be responsible. If we make bold recommendations and are influenced by the sales talk and the exaggerated advertisements, the farmers no doubt will suffer losses. Such actions will produce ill effect to the progress of agricultural mechanization and make our original program gone

awry.

E. Farm machinery manufacturing should be linked with the agricultural needs

We think highly of the enthusiasm on manufacturing of farm machineries displayed by the machinery manufacturing industry of Taiwan. But we feel it improper to determine the farm machineries to be put on market by the production facility and capacity of the machinery manufacturing industry and not according to the needs of the agricultural industry or to assume the future needs of the agricultural industry to be the present needs. Mechanized agricultural industry and farm machinery manufacturing industry should supplement each other and go hand in hand. We should realize especially that the potential users of farm machineries are those diligent farmers who have limited purchasing power and who should need some more time and education to accept such new idea. In other words, there is not a ready market for the farm machineries yet. Mechanized farming is only one of the means of promotion of agricultural production and is not an end in itself. The supply of farm machineries is but to provide the necessary tools to help mechanize agriculture. Therefore the manufacturing of farm machineries should be geared to the agricultural needs and not entirely aimed at sales. Otherwise, it would be putting the cart before the horse.

As to the manufacture of farm machineries, we by no means doubt the ability of the machinery manufacturing industries in Taiwan. However, if we take the bicycle manufacturing industry for instance, we find that although bicycles are far simpler than power tillers and have assured markets, yet it took the bicycle industry considerable efforts and cooperation from all sides and much improvements through the years, before it met with some success. Farm machinery manufacturing is confronted with three other preblems that bicycle making did not have:

1. *Materials*—Farm machineries come into direct contact with the soils mixed with sands and gravels. Therefore we have to select the best suitable materials, not only something that looks like farm machineries but cannot stand the constant wearing.

2. *Design*—The bicycle industry does not need more variation in designing because it has almost developed to the ultimate stage, and since the roads in Taiwan are not much different from roads in other countries, it is only necessary to manufacture according to foreign designs. In the case of power tillers

and other farm implements, however, we have to make them to suit the agricultural conditions of Taiwan. This is made more difficult as power tillers for both paddy and upland fields are in the initial stage of use in other countries, and many more improvements still have to be made.

3. *Price*—When our costs of production of farm implements are higher than the prices of imported farm machines, we cannot make the farmers use the domestic products, lest they would add to the costs of production, which in no means is expected from agricultural mechanization,

We hope the manufacturers of farm machineries will pay attention to these points at the outset. We believe that when the farm machinery manufactories of Taiwan have established themselves, they will be for some time to come, like our bicycle industry. They would be buying the engines, essential materials and some parts from abroad and only do the machining and assembling locally. But even so, we would have saved the foreign exchange that otherwise had tc be spent to import the entire power tillers from abroad.

IV. Possibilities of Over-all Agricultural Mechanization

In the foregoing sections, we have discussed the problem of mechanization of farming centering on the use of small power tillers. We hope the foregoing will have explained clearly enough that it is possible to use power machineries in Taiwan. As to over-all mechanization of agriculture, it will be a series of chain reactions set off by the use of power tillers. It will take place only after the power tillers are firmly established in the rural areas of Taiwan. For instance, the farmer who already has a power tiller will only need to buy a pump unit and a spray gun to make up a power sprayer. He does not have to buy another engine. The engine of the power tiller can also be used for propelling water pumps. The fan mills, rice milling machines, straw rope machines, sweet potato slicing machines, etc. now used in the country can also be powered with the tiller's engine after power transmission is added. The small handcarts, after changing the handle to hitch, can also be driven by the tillers. The same engines may also be useful on machines for seeding, weeding, harvesting, feed-cutting, ramie decorticating, grading and cleaning which will be developed later. By then, farmers will want power machinery for all the farm work. The responsibilities of the farm machinery engineers will be how to renovate the present farm implements and properly power them, and to develop more machines to save more animal power and human labor. The prospect of the rural village by then will be very bright. The use of the small power tillers is there-

fore the key to the over-all agricultural mechanization in rural Taiwan.

V. Economic Aspects of Mechanized Agriculture

Lastly, let us evaluate agricultural mechanization from the economic point of view. To take the small power tillers for instance again. The results of deep plowing done by farmers Wu Pu-chao, You Wen-pin and Chiang Wen-an of Yuanlin Chen, Changhwa Hsien, are:

Depth of plowing	Rice harvested per ha. of paddy field
3.5 Taiwan inches	7,600 Taiwan catties
4.5 〃 〃	8,800 〃 〃
5.5 〃 〃	9,500 〃 〃
6.5 〃 〃	9,800 〃 〃

There are similar records during the Japanese occupation period with very high rates of increase, about 30% to 50%. Making a conservative estimate, if the average depth of cultivation by draft cattle in Taiwan is 4 Taiwan inches, while the depth plowed by power tiller in the same field is 5 Taiwan inches, the increase in yield for the first rice crop will be 1,000 Taiwan catties (or 597 kg.), and for the second rice crop 800 Taiwan catties (478 kg.). Each power tiller will cultivate 2.5 ha. per season (assuming one tiller jointly used by two farm families). Fifty thousand tillers will cultivate 125,000 ha. of land per season. The output increase, if calculated at 14%, for the first crop will be 74,000 m/t, and for the second crop 59,000 m/t. The total increase in rice production for the two crops from the 125,000 ha. of land cultivated by power tillers will be over 130,000 m/t. Even if this figure is cut down by half to only 7% increase, we still have 65,000 m/t in increased rice output. This additional 65,000 m/t of rice from no extra land will have undeniable effect on improvement of the food situation in Free China. This quantity of rice if exported to foreign countries will earn foreign exchange amounting to 6.82 million US dollars (70% of the paddy rice will become polished rice, selling at US$150 per ton). Even if the rice is not to be exported, the increased value is there.

On the other hand, let us calculate the amount of foreign exchange to be spent for purchase of 50,000 power tillers. At present, we have to buy the whole machine from abroad, for instance each Merry Tiller costs about US$240. Under this circumstance, we may have to import 1,000 tillers. Later, we only have to purchase the engines and some of the parts from abroad, at the cost of US$180 per unit. We presume that 9,000 such tillers will be sold in the rural areas at

this stage. In a still later period, most of the parts may be manufactured in Taiwan except for the engines and some important materials, each power tiller will then need only US$100. The 50,000 power tillers will cost Free China a total of US$5.86 millions, which is 86% of the increased value of rice derived from the use of the power tiller in one year. Setting the serviceable life of a tiller at 6-8 years (ordinarily, tractors have a service life of 12 years. The small power tillers working in paddy field and operated by inexperienced farmers will of course have shorter service life.), we can well see the actual profit of using power tillers. Furthermore, it is not impossible to manufacture such engines in Taiwan and further reduce the amount of foreign exchange expenditure. These calculations do not include the value created by using the power tiller for other farm works, which is hard to estimate but should not be neglected.

The power tillers have another value which cannot be definitely calculated at the present time. That is, after harvesting, the tiller can prepare the land much quicker than with cattle and thereby greatly increase the possibility of planting an intermediate crop of short growing period that will again increase the intensity of land utilization.

The effects of use of power tillers other than agricultural are: (1) It may help the development of rural industries. (2) It will help in the development of the farm machinery manufacturing industry in Taiwan. Estimating that a small power tiller with all implements, sells for NT$10,000 per set, 50,000 power tillers will cost a total of NT$500 million. This will enable the farm machinery manufacturing industry of Taiwan to gain a firm footing and thence to further expand.

The Government is now contemplating extending the period of compulsory education to nine years and enforce two years' military service for every man of draft age. These measures, when carried out, will take away an average of five years from a man's time in agricultural production. The use of power tiller under these circumstances will help to keep up the productive power of the rural areas.

Judging from all criteria, mechanization of agriculture is beneficial in all respects. Although a considerable sum of foreign exchange will have to be expended at the outset, this certainly should be considered a profitable investment.

VI. Conclusion -- How to promote agricultural mechanization

With the advance of agriculture in Taiwan, and the need of increased pro-

duction, mechanization of the agricultural industry has aroused the interest of the farmers and the general public. The pessimists claim that since we have a large population which the farms are small in size and the supply of foreign exchange for machines and fuel is not assured, it is not feasible to carry out agricultural mechanization. The optimists consider it easy for us to follow the worldwide trend and, with the endeavors of our machinery industries, agricultural mechanization can surely be attained. We have expounded the pros and cons on this subject with the use of small power tillers in the fields as a starting point. A summary of the points discussed above are:

1. Although we have abundant manpower, we do not have enough draft cattle. The surplus manpower cannot replace the needed animal power. The first step of mechanization of agriculture in Taiwan consists of the use of 50,000 small power tillers to make up for the shortage of the draft cattle, so that adequate power supply will be available to the farmers for promotion of our agricultural production.

2. Although the farms are small, the power tillers to be used can be easily operated in the small farms. They can be used in all paddy and upland fields where the buffalo can work.

3. If use of small power tillers is extended gradually, the supply of fuel will not be too big a problem. It is necessary that we first accept the idea of power farming and thence plan the gradual extension of power tillers and the supply of fuel to meet the actual needs. At the same time, the fuel substitute problem should be studied.

4. Power tillers to be used must be those that can fit into our agricultural conditions. We must be careful in selecting the right type of power tillers. We should allow sufficient time for farmers to learn how to use power tillers to replace present cultivation tools, even if we want to extend the use of power tillers as soon as possible. It is our sincere hope that the agriculturists and agricultural engineers exert their redoubled strength to solve problems that confront the farmers during the period of transaction on the use of power tillers so that mechanization of agriculture in Taiwan may be satisfactorily carried out.

5. We hope that the farm machinery manufactories coordinate closely with agriculture and the two supplement each other. The farm machinery manufactories should not concentrate on making profit for the present duration. If we rush the program too much, we may be impeding the normal growth of agricultural mechanization.

6. The use of small power tillers is the key to the solution of the problem of overall agricultural mechanization. When the power tillers are used, other power machineries for cultivation, pest control, processing, etc. will be automatically adopted in the rural area.

7. According to an estimate made by the author previously, the foreign exchange that has to be spent on purchase of power tillers can be compensated with the increased rice output within a year (two crops of rice). This would be a very profitable investment on the part of the government, as it will not only increase agricultural output but also help develop the agricultural machinery manufacturing industry in Taiwan.

As to the approaches to the mechanization of agriculture, we wish to point out the following:

1. As the tillage tools matched to the power tillers are different from the conventional animal drawn farm implement, it is the responsibility of the government agricultural agencies to study how to replace the conventional farm tools with the modern ones and obtain same or better results. Only after this is done can we encourage the farmers to adopt power tillers and teach them how to use power tillers. In other words, research and education are prerequisites to the large scale extension of power farming machineries.

2. Farm machinery manufacturers should work out a plan for installment payment, and the government agency in charge of agriculture should formulate some procedure such as extend loan to farmers for purchase of power tillers, so that those who cannot pay ready cash for the power tillers can still afford to use them.

3. Farm machinery manufacturers should pay attention to the servicing of the machines before and after the sale, and to keep its servicing force up with the government extension plan. It is also necessary for them to set up service stations in the extension areas to teach the farmers how to operate and care for power tillers at the time of sale, and after the sale to supply spare parts and take care of repairs. The supply of fuel should also be geared to the tempo of the agricultural machinery extension schedule.

4. In starting extension of power tillers, we advocate concentrated efforts, i.e. to select several localities from the main agricultural areas where we can concentrate the available efforts to train farmers how to operate the power tillers and arrange to supply fuel and spare parts and repair service to the power tillers owned by farmers in these localities. When success is attained in these

experimental localities, the work can then be gradually extended to other areas so that the same troubles may not come up again.

The four points elaborated above are aimed at parallel undertakings in technique, economy and field implementation. The extension may be slow if followed along these lines, but, after the initial stage is over, it will be very appreciably stepped up. At this point, the author feels that he has painted a rosy picture of mechanized agriculture in Taiwan. In fact, the agriculture in Taiwan is on the threshold of mechanization. JCRR has now granted power tillers to 13 agricultural research stations and institutes through PDAF. This grant is aimed at a province-wide experiment on the adoption of power tillers with individual farm or 2-3 small farms in group as an operation units. The results so produced may serve as the farm owner-operators' direct reference. JCRR has also commissioned PDAF to conduct training classes on operation and care of such power tillers, expecting the trainees not only to be able to use the tillers but also to conduct demonstrations to farmers. PFA has imported some 250 sets of Japanese modified Merry Tillers for sale to farmers. In its sale plan, an installment payment plan has also been established. With the concentrated efforts of all concerned, we are sure it will not be long before Taiwan's agriculture will step into this new era of mechanization.

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PART TWO

HOW TO MECHANIZE THE AGRICULTURE IN TAIWAN

—With reference to the preliminary results on test use of small tractive and rotary type power tiller—

Chinese Edition, March 1957
Revised English Edition, September 1957

THE MARCH OF TIME

FOREWORD

In April 1956, Mr. F. C. Ma, Specialist of the Plant Industry Division of the Joint Commission on Rural Reconstruction (hereinafter referred to as JCRR) worte an article entitled "On the Agricultural Mechanization in Taiwan (Part One, Can the Agriculture in Taiwan be Mechanized)" (JCRR Special Publication Series No. 14), describing the small power tillers the United States and Japan made during World War II. In that article, Mr. Ma pointed out that there is a high potentiality on adoption of small power tillers in Taiwan, where though man power is plentiful, there are insufficient draft cattle and limited arable land with a very heavy and complicated cropping system. Mr. Ma's viewpoints found support and endosement in various circles, notably the Taiwan Provincial Department of Agriculture and Forestry (PDAF), the Taiwan Provincial Food Bureau (PFB), Taiwan Provincial Farmers' Association (PFA), the Taiwan Land Bank (TLB), and the Industrial Development Commission (IDC).

Although the circumstances in Taiwan are favorable for the use of small power tillers, whether or not the farmers in Taiwan will promptly accept them as substitute for cattle, which have been in use in rural communities since time immemorial, still depends on the following conditions: (1). the power tillers should have definite advantage over buffalo in several aspects, e.g. the operational cost of the power tiller must be lower than that of buffalo; (2) the power tillers must be able to do most of the work done by the buffaloes; (3) repair service and spare parts for power tillers must be readily available; (4) fuel supply must be assured and at a stable price level; (5) power tillers must be produced locally at prices that farmers can afford; (6) good technical extension personnel must be available to teach farmers how to use and take care of the power tillers.

Keeping in mind the above-mentioned requirements, JCRR in the past year has collaborated with agencies concerned and together got under-way some preparation works for introduction of power tillers to Taiwan. Fristly to test and demonstrate the workability of these tillers under local farming conditions, 13 Merry Tillers were purchased from PFA and donated to 13 agricultural research institutes and agricultural improvement stations of PDAF. These power tillers were put into test use in various crop fields of different soil conditions to ascertain the feasibility, advantages and the cost of each type of farming operation as compared with buffaloes. Soon after the results of the preliminary test were known, demonstrations were held at many places and observ-

ations were made to determine the efficiency and economic feasibility by using these power tillers all year round on fields of contracted farmers. Studies on improvement of farm implements attached to the power tillers to meet the farmers' needs were also started. Secondly, JCRR subsidized a PDAF training class and to train the immediate research and extension presonnel on the use of power tillers. Thirdly, the JCRR specialist participated in the Machinery Manufacturing Industry Promotion Group of IDC to discuss how to make and improve power tillers in Taiwan. And finally together with PDAF, PFA and the China Petroleum Corporation, JCRR initiated a plan for rationing of fuels to power tillers. The plan has since been revised and approved by all the parties concerned. (not yet promulgated by the Taiwan Provincial Government.)

In this article, Mr. F. C. Ma has made a summarized report on the result so far obtained from field observations on testing of power tillers in the past year. He has also, made recommendations regarding the more suitable type of power tillers for Taiwan and the ways and means to extend their use. This article digests the results of the studies, experiments and demonstrations conducted by many technicians in Taiwan during the past year and therefore is very valuable. The data contained in this article point out the more concrete measures that should be adopted for promotion the use of small power tillers in Taiwan.

Mechanized farming has just begun in China. We shall need carefully planned schedule and close coordination from all parties concerned. It is essential that we refrain from being satisfied with preliminary results and hence indugling in overly optimistic planning and promotion of ambitious programs at this moment.

Toward this point JCRR suggests the followings:

(1) Agricultural agencies should (i) begin to demonstrate power tillers of suitable type on a larger scale. The essential thing is to tell the farmers how to use power tillers the year round to do different kinds of work in their own farms, (ii) to continue designing new farm implements attachable to the power tillers and adaptable to the conditions in Taiwan. The ultimate aim is to make the power tillers excel the buffaloes in work performance in the farm. (iii) to continue training technical workers to assure adequate number of extension and repair personnel. The more the above works is expedited, the better coordination from the industrial and financial organizations may be expected.

(2) IDC should advice machine manufacturers of higher caliber to begin

trial manufacturing of power tillers and attached farm tools, keeping in mind the general requirements as discussed in this article. Machines locally made should be tried first by agricultural experiment stations and then put to demonstration if they are proven to be satisfactory or promising.

(3) Banks should extend long term credit to help the purchase power tillers from the PFA stock.. If the sales proved to be satisfactory, more will be imported until local products can substitute the imported power tillers.

(4) The agency in charge should promulgate regulations regarding the allocation of fuel for power tillers so that the cost of operation of power tillers will be reduced and extension of the power tillers will be facilitated.

H. T. Chang
Chief, Plant Industry Division
Joint Commission on Rural Reconstruction

March 1 1957

On The Agricultural Mechanization in Taiwan

Part Two

How To Mechanize the Agriculture in Taiwan.

—With Reference to the Preliminary Results on Test Use of Small Tractive and Rotary Type Power Tillers—

I. Introduction

In view of the inadequacy of power for rural Taiwan and the difficulties in increasing the number of draft cattle, JCRR has been contemplating for a long time about the ways and means to adopt power machineries for agricultural production. In 1954, when the author was sent with other JCRR personnel to Japan to attend the fourth meeting of the International Rice Commission of Food and Agriculture Organization of the United Nations, he was also instructed to find out the situation about use of power tillers in Japan. After the author came back from the trip, he suggested that JCRR subsidize the Provincial Farmers' Association (PFA) the purchase from Japan of a typical Japanese type power tiller, (driven and rotary tilling type power tiller represented by the 5 HP Kubota power tiller) and a US and Japanese combination type tiller, (tractive and rotary type power tiller represented by the 2.5HP Merry Tiller produced by the Saiosha Works Company Ltd. of Japan in colaboration with the Merry Manufacturing Company of the USA) for test use and preliminary observation.

Upon arrival in Taiwan the Kubota tiller was sold on an instalment payment plan by the PFA to farmers Wu Pu-chao, Yu Wen-pin and Chiang Wen-an of Yuanlin Chen, Changhua Hsien for intensive use, and the Merry Tiller was exhibited and demonstrated at various public meetings by the PFA. The general comment was that the Merry Tiller would definitely be more acceptable to farmers in Taiwan because of its light weight, compact size, easy operation and high maneuverability in small fields (therefore can be used for much more kinds of work in the farm) and, most important of all, lower cost. PFA thereupon imported 250 Merry Tillers for sale to farmers. To further ascertain the serviceability and adaptability of the tractive and rotary type power tiller, JCRR subsidized the purchase of 13 Merry Tillers by PDAF from PFA and allocted them to the TARI (Taiwan Agricultural Research Institute), its three Branch Stations

in Chiayi, Tainan, and Fengshan; and seven District Agricultural Improvement Stations at Taipei, Hsinchu, Taichung, Tainan, Kaohsiung, Taitung, and Hualien; the Seeds & Seedling Multiplication Station of PDAF and the Tobacco Research Institute of the Provincial Tobacco & Wine Monopoly Bureau.

The purposes of this test are twofold:

(1) To find the proper way of utilizing power tiller and attached implement on the farms of Taiwan

(2) To find the differences in work efficiency and economic value between using power tillers and draft cattle.

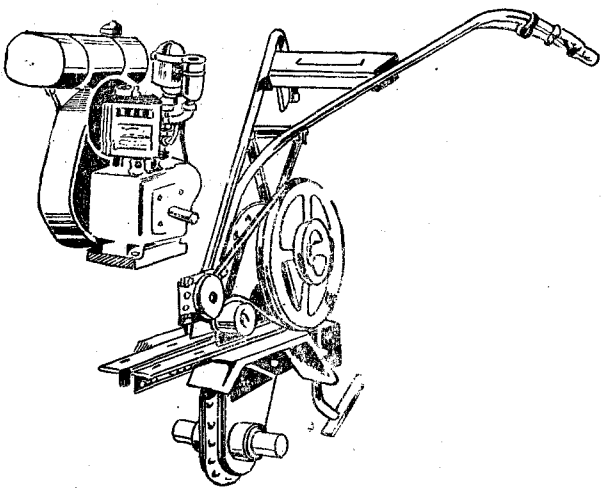
In April 1956, JCRR published in its special publication series, part one of this article "Can the Agriculture in Taiwan be Mechanized" before launching the province wide tests of power tillers, in order to aroused the interest of the farmers and the industries toward the power tillers. In May, 1956, a training class was conducted by PFA and the Provincial Taoyuan Vocational Agricultural School on how to operate and care for the power tillers. The purpose was to train the power tiller operators for the 13 experiment stations undertaking the field test. By the end of June, 1956, when the various agencies started field test of the power tillers, JCRR invited Mr. Peng Tien-sung, farm implement teacher of the Taoyuan Vocational Agricultural School to visit the thirteen agencies concerned to give on-the-spot instructions. The author also held discussion with the technical personnel in charge and power tiller operators at various station whenever possible. Some preliminary results were obtained from the tests in the past year. Although they can not as yet serve as dependable data until sufficiently supplemented and borne out by further tests and studies, however one fact is certain, that is small power tillers can definitely be used in Taiwan.

Following is a report written on the basis of the preliminary results, to serve as reference material for those who are interested.

II. Brief description of the power tiller employed in field test.

(1) **Power Tiller** (Merry Tiller model MT-3)

1. The body: length 155 cm. (including handle), width 70 cm, height 100 cm, total weight (including engine and wheels) 57 kg. (pic. 1)
2. Engine: Clinton (U.S. made) or Shibaura (Japanese made), both are air-cooling four stroke cycle single cylinder gasoline engines, of 2.5 rated HP.



Pic. 1. Body and engine of Merry Tiller

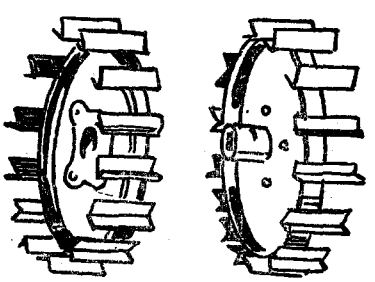
3. Transmission method: two step speed reduction transmission, using one V-belts (54") and two heavy duty chains (5/8" and 3/8" roller chains)

4. Speeds: the speed can be changed by pulleys of different diameters. There are three forward speeds—4.3 km, 5.4 km, and 15 km per hour. No backward arrangement.

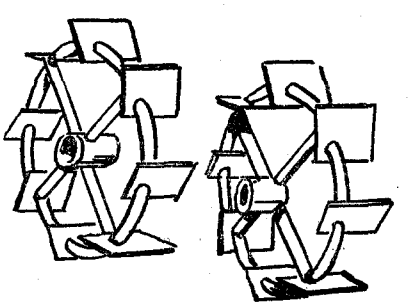
(2) **Attached farm implements:** (limited to those being used and tested at these stations)

1. *Smooth rim wheel:* made by the PFA Machine Shop, intended to replace the pneumatic rubber tire wheel for travelling on roads.

2. *Steel lug wheel:* for use in field work in general. The angle iron lugs on the rim of the wheel reduce slip while travelling (Pic. 2)



Pic. 2.

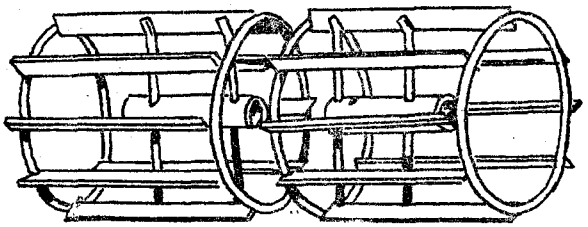


Pic. 3.

3. *Pipe wheel:* primarily for use in paddy field. The big flat square lugs on the pipe rim increase the weight supporting area and prevent bogging. (pic. 3)

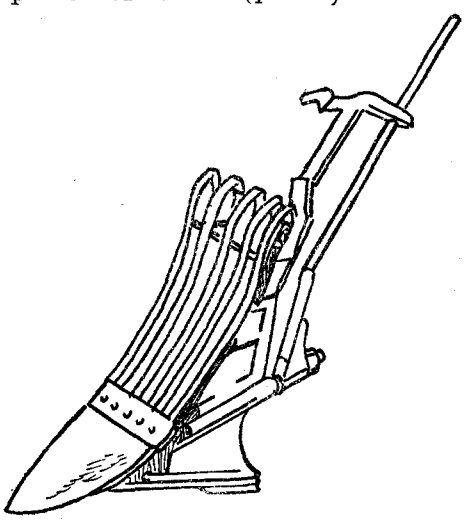
4. *Cage shape wheel:* used in paddy fields or very soft sandy land. When

used in paddy fields, it can primarily break clods, level the surface and mix straws into the earth. (pic. 4)



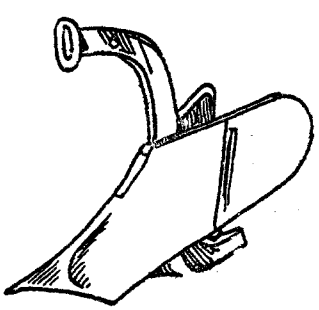
Pic. 4.

5. *Reversible plow:* originally produced by the Takakita Agricultural Implment Manufacturing Company Ltd. The plow is able to turn soil to either sides by turning the moldboard to that side. It is convenient to operate in small pieces of fields. (pic. 5)

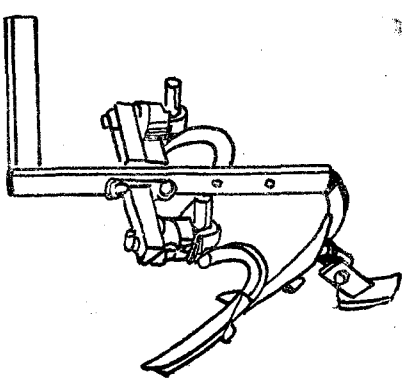


Pic. 5.

6. *Middle-buster:* can be used for opening furrow and hilling ridges in upland fields. (pic. 6)

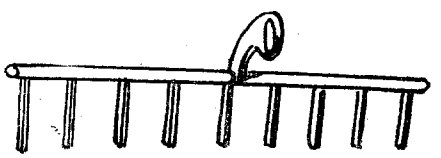


Pic. 6.

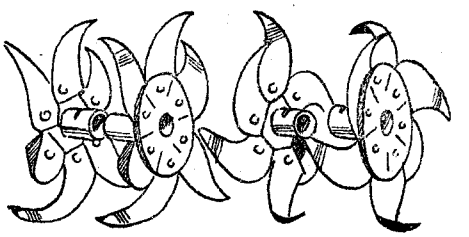


Pic. 7.

7. *Cultivator:* used for intertilling and weeding in row crop field (pic. 7)
8. *Spike harrow:* attached to the rear of power tillers, can be used together with cage shape wheels on paddy fields, and with breaking rotor on dry fields. It is used to break up clods and level the fields. (pic. 8)
9. *Breaking rotor:* this tool belongs to the "traveling while working" kind, used for breaking the clods (pic. 9)

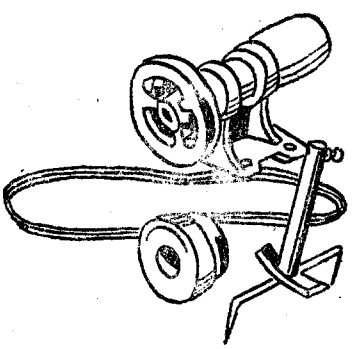


Pic. 8.



Pic. 9.

10. *Power-take-off:* This equipment transmits power from the engine, by belts and pulleys, to stationary machines. It is different from the conventional power-take-off of tractors. (pic. 10)



Pic. 10.

III. Summary report on trial use of power tillers in paddy fields

Power tillers are mostly used for land preparation on paddy fields as the row distance of rice seedlings is narrow and it is impossible for power tillers to get into the field after seedlings have been transplanted. The same was true with the Merry Tillers we employed. The processes of preparation of paddy fields in Taiwan differ in localities and for the first and second crops, but we can divide the processes into some distinct operations, ie., plowing, pulverizing (puddling) soil, and levelling land.

(1) Plowing

1. Method of mounting and adjusting the reversible plow:

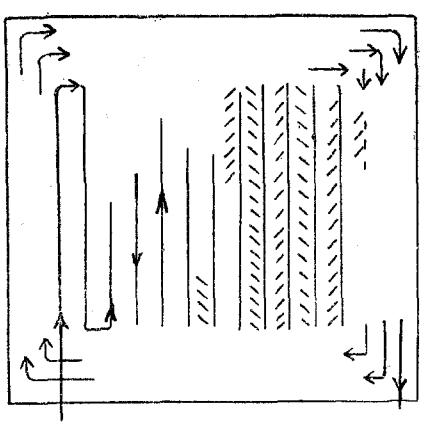
Suggested methods by TARI are as follows:

a. If the furrow slices are to be turned to both sides, the reversible plow should be hitched to the middle hole of the universal hitch. If they are to be turned to one side, the plow should be hitched to the second hole of the universal hitch on the side the furrow slices are to be turned. (E.g. if furrow slice is to be turned to the right side, the plow should be attached to the right side second hole of the universal hitch).

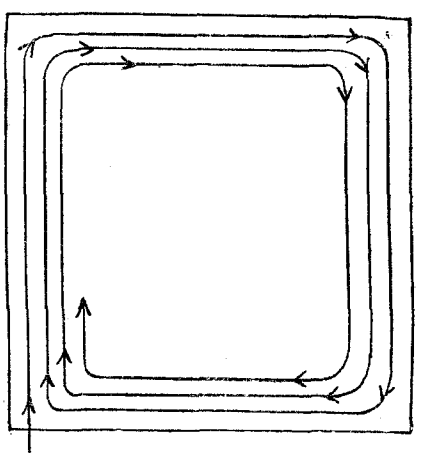
b. Mount pipe wheel to the center hole of the axle tube. (the third hole counting from outside).

c. The balance weight to be used will depend on the soil. In paddy fields, the 20 kg piece is usually ample.

2. Method of plowing: Method of plowing means here laying out of the field and subsequent working. TARI is for the combination method, (pic. 11) While other stations are for round-and-round plowing method starting either from the outside or the center (pic. 12)



Pic. 11.

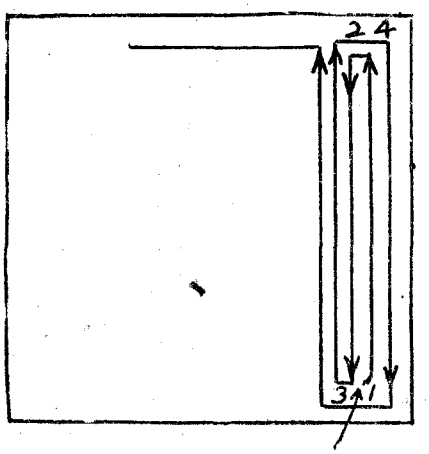


Pic. 12.

Both methods are feasible. However, the conventional method of plowing, especially the way in starting break up the ground (pic. 13) when cattle is used, is not suitable for power tillers.

Recommendations of TARI regarding the combination method of plowing are:

a. Divide the field to be plowed into two or three plots of about the same size and plow the plot in turn to avoid unnecessary none working trips.



Pic. 13.

b. Reserve enough space at both ends of the field to allow the power tillers to make turns. Allow space also on both sides of the field to enable power tillers to circle the fields.

c. The depth of plowing can be adjusted by adjusting the depth lever. Five turns to the right will increase the depth of plowing to one inch. Turning to the left will reduce the depth of plowing. Attention should be paid to the fact that the depth of plowing should be gradually increased every year, it should by no means be suddenly increased.

d. The furrow wheel should be placed inside the plow furrow, the land-side of the plow should hug the furrow wall and furrow bottom firmly.

e. The operator only needs to control the power tiller lightly to maintain a straight travelling line, to lift handle slightly reduce the depth of plowing and press down to increase slightly the depth of plowing (this is just the the opposite as when using cattle for plowing). However, the recommended standard method still is adjusting the depth lever.

f. After plowing, drive the power tiller around the edge of the field in circles, extending until the wheel reach the ridge of the field. Then the plow will be moved to the outermost position on the universal hitch so that the outer edges of the field may be plowed.

g. Plowing should be done at low speed. Use of higher speed ought to be absolutely refrained from in order to maintain the service life of the machines.

One thing the farmer ought to note about round-and-round method of plowing is that, if the plowing is done from the center of field to the outside this time, the next time he should go from the outside to the center. This is

to prevent the soil from being gradually gathered in the center of the field or plowed to the sides of the field. For other matters, refer to the combination method of plowing. This method is very convenient in plowing small or awkward shaped plots.

3. Method of plowing fields of special condition:—The followings are suggested by Mr. Peng Tien-sung of the Taoyuan Vocational Agricultural School:

a. Plowing fields with heavy clayey soil: Drain the field and let it dry to the stage of about to crack, and allow two inches of water to soak the fields for three to four days. Start plowing. Use steel lug wheel to facilitate work. Heavy clayey soil should never be plowed when it is half dry. If plowed at such condition, large clods will be turned up because of the sticky nature of the soil. These big clods tend to gather along the plow beam and prevent smooth turning of furrow slice. When this happens, wheel slippage increases and makes travelling difficult.

b. Plowing fields with light sandy soil: Use steel lug wheel if the earth is not too soft, use pipe wheel if the soil is very soft.

c. Plowing deep muddy paddy field: When the soft loose soil of the field reaches a depth of one foot or deeper, even when using pipe wheel, the soil still does not have enough supporting strength and the power tiller will bog down. Therefore it is best to use cage shape wheel directly puddling the soil without plowing. The cage shape wheels presently available in Taiwan are designed for ordinary fields and may also bog down if the case in really bad. Therefore in the very deep muddy field we will need the specially designed cage shape wheels.

d. Plowing the field covered with straw: In the northern parts of Taiwan, for returning organic matters to the soil, the practice is to put the straw in the fields after harvesting the first rice crop. To plow the field, one has to turn the straw together with the furrow slice. The straw often gets entangled in the wheels and axle, and this will obstruct work. Therefore it is best to use the straw as compost and plow the compost into the field when it is sufficiently decomposed. Or, the next best method is to cut the straw in sections and throw them into the fields along the direction of plowing. If using the conventional method of plowing, it is better not to put straw at the breaking line, because so doing tends to make the straw roll on the wheels.

e. Plowing field planted to green manure crops: It is very difficult for the small power tillers to be manuevered in fields with green manure crops as

high as two feet and up. So when power tillers are to be used, it is best to cut the green manure plants into sections and scatter them in the fields before plowing as suggested for straw. Low and prostrate green manure crops do not have to be cut up but should be pressed down before plowing. The suggested method is to use different wheels on the sides of the power tiller, for instance, cage shape wheels on the land side, and use steel lug wheel on the furrow side. Adopting the round-and-round plowing method, the cage shape wheel will press the green manure crops to the ground, and the steel lug wheel in the furrow can keep the power tiller travelling ahead. It is always possible that green manure crops or straw will get involved in the wheels or axles of the power tillers. Therefore farmers should always carry a knife or a sickle for cutting off the entangled stalks. The curvature of the slatted moldboard of the reversible plow can be adjusted to a certain extent. When plowing green manure fields, do not forget to adjust the curvature of the moldboard to the steepest possible slope to facilitate turning over the furrow slices and the green manure plants.

f. Second plowing of fields: In the southern parts of Taiwan, plowing is done twice, once right after the harvesting of the first rice crop, when the field will be followed, and the second plowing starts when the second crop season comes. Knife tooth harrows, comb harrows and pulverizing rollers are used to complete breaking, pulverizing and levelling work when baffaloes are employed. When using power tillers to plow such uneven fields, the wheels can not grab firmly and steadily, while the chain case is so low that it will frequently get to the top of some big clods, slippage of wheels will occur, and work will be retarded. In these fields, therefore, it is best to get the field levelled first. In fields soaked with water after the first plowing, cage shape wheel may be used to level the ground once. In fields which remain dry after the first plowing, breaking rotor may be used to prepare the field once to ease the plowing job that follows.

The above suggestions are derived from short period experiments. Satisfactory operation and utilization of the power tillers have to be learned by the users from experience. The above are general suggestions and do not have to be followed strictly step by step.

4. Comparison of paddy field plowing with power tillers and with draft cattle: According to the reports submitted by the various experiment stations, 18-25 work hours will be needed for plowing one hectare of paddy field to 5-6 Taiwan inches. While 35-50 working hours will be needed to plow one hectare of land with draft cattle to the depth of 4-5 Taiwan inches. The

number of work hours for both, will vary of course according to nature of soil texture and other conditions of the fields. But in general, power tillers will plow one inch deeper than draft cattle and for only half as much time. One report, however, differed from the majority. The Tobacco Research Institute at Taichung reported similar depth achieved by draft cattle and power tiller, although the power tiller can do the job a little faster. Further study on that case revealed that the paddy fields in the Tobacco Research Institute had deeper muddy top soil than ordinary paddy fields which accounts for the result. Another advantage on the use of power tiller unanimously agreed upon by all the stations is that, no matter how small in size and irregular in shape the fields are, plowing closer to the corners and sides of the fields is achieved by power tillers than draft cattle. This is one point on which the users express the most satisfaction.

(2) **Breaking, pulverizing and leveling soil** (i.e. secondary land preapration):

These are the sequence of operations when using draft cattle, but are done in only one step when using power tillers. Therefore breaking, pulverizing, and levelling are discussed together here.

1. Mounting secondary land preparation farm tools:—TARI suggests the following points:

a. Mount cage shape wheels to axle tubes, balance weight to balance bracket.

b: The cage shape wheel will bury straw stalks and grasses in earth in the first operation. Pulverizing will be completed during the second operation.

c. If spike harrow is attached to the rear in addition to the cage shape wheel, each operation will accomplish the approximate performance of knife-tooth harrow, comb harrow and pulverizing roller when draft cattle is employed.

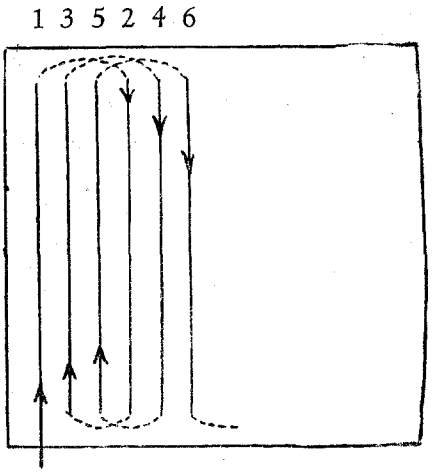
d. It is suggested that the process of secondary paddy field preparation with power tiller, may include: use cage shape wheel puddling the field lengthwise and widthwise once each, and then add the spike harrow and travel across all over the field once to complete the operation.

e. The balance weight to be used depends on the type of work to be done and the nature of soil. 20 kg weight is needed to bury the straw into the earth, 10 kg weight is needed while work on soft soil, and 20 kg weight for levelling the soil. If slippage of wheels increases, balance weight should be increased by 10 kgs or the balance bracket should be extended to balance it up.

f. When levelling pulverized soil, use the second (medium) speed in

general. However, the low speed may be used on soft soil.

g. The field layout and sequence of work for secondary land preparation on paddy field is suggested in Picture 14.



Pic. 14.

2. Comparison of power tiller and draft cattle for secondary land preparation of paddy field:

When employing draft cattle, first use knife tooth harrow to break up soil clod, then use comb harrow to pulverize soil, move soil from higher spot to fill lower spot, and use polverizing roller to level field. As usual, use of a knife tooth harrow and comb harrow once each lengthwise and across the field and use of pulverizing roller once in the field are considered enough. The total working hours will be 35 to 50. With the power tillers, the method of operation is entirely different as with buffalo, which we have explained in detail in the foregoing paragraph. The total working hour will be 26 to 40. From this we can see that when pulverizing and levelling soil, the power tiller and the draft cattle are more comparable in efficiency. The reason is that the cage shape wheel and the spike harrow attached to the Merry Tiller both have a narrower work width than the knife tooth harrow, comb harrow, and pulverizing roller pulled by the cattle. Furthermore, the power tiller is harder to drive on fields just plowed up, slippage of wheel will occur. Therefore it does not travel as steadily as the cattle, and much speed is lost therefrom. As to the quality of work, according to the Taichung District Agricultural Improvement Station, the cage shape wheel presses the grass deep into the soil so that it will not come up in two weeks' time. Ordinary pulverizing roller levels the field better but it will not press the grass into the soil as deeply, so that in a week's time,

the grass will come out afresh. For this reason, farmers like the combination of power tiller and cage shape wheels very much. However, the spike tooth harrow attached to the power tiller is narrower in working width and has less number of teeth, and these teeth are shorter, so that its performance is considered inferior to that achieved by the comb harrows drawn by buffaloes. Toward this attachment farmers expressed their disappointments. Some farmers in Ilan attached the animal drawn comb harrow to the power tillers. And some farmers in Pingtung attached the levelling pole originally attached to the animal drawn comb harrow to the spike harrow of the power tiller and achieved general improvement in efficiency although the degrees of success attained differed according to individual skill. In general, the farm tools used with the Merry Tiller are satisfactory for puddling and pulverizing soil, but they leave much room for improvement for levelling the field, which is as yet better done with conventional implements.

IV. Summary report on trial use of power tillers on upland fields

(1) Plowing

1. Selecting, mounting and adjusting of farm tools—Suggestions made by TARI are as follows:

a. Steel lug wheel: Attach to the third hole (i.e. the middle hole) of the axle tube for use on dry land.

b. Pipe wheel: Used when field is wet attach in same way as mentioned above.

c. Reversible plow: Attach to the center position of the universal hitch.

d. Breaking rotor: Put the knife point in the direction of travelling. The blades of the rotors should be arranged so that they are parallel. Place the shorter axle tube on the inside, the longer axle tube on outside end of the axle. The distance between the rotors should be adjusted according to the nature of soil.

e. Balance weight: 10 kg weight for sandy soil, 20 kg for clayey soil is recommended for general conditions, but ought to be adjusted according to the field condition.

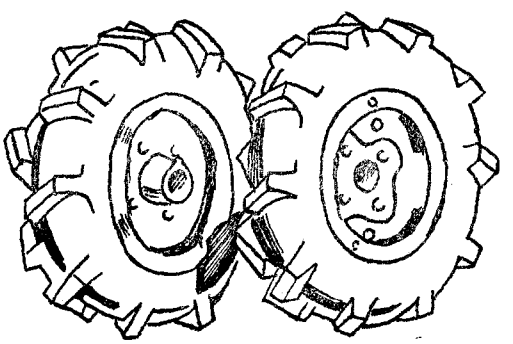
f. Speed of travelling: Take the first (low) speed for plowing, second (medium) speed when using breaking rotor.

2. Method of plowing fields of special conditions: The following are sug-

gested by Mr. Peng Tien-sung of the Taoyuan vocatiaonl Agricultural School.

a. Fields with heavy clayey soil: Plowing of field with heavy clayey soil is best done when the moisture content of the soil is suitable (about 60-70% of the saturation capacity). If the soil is too dry, the plow can hardly penetrate into it, while if the soil is too wet, the wheels of the power tiller will be mud -encircled and slippage will occur which practically prevents work. Grass in the fields will also likely get entangled in the wheels and the axles and obstruct works. As to the selection of wheels, it is best to use steel lug wheels on soil of moderate moisture content and pipe wheels for slightly over-wet fields.

b. In fields of sandy soil: It is generally easier to plow sandy soil. But when the soil is too dry and very light, it produces very little friction and supporting force; even the steel lug wheels will slip. Using pipe wheels will reduce slippage, but, because it has less number of large lugs, therefore will not produce smooth rolling and the power tiller will shake violently. We believe pneumatic rubber tires should be used on sandy soil to increase the area of contact. (see pic. 15)



Pic. 15.

c. In fields covered with vegetations or planted with green manures: The method will follow roughly that used in plowing paddy field with green manure crops as mentioned above. However, attention must be paid to the moisture content of the soil as it will affect the work efficiency greatly. Also, if the green manure crops are drilled, the between wheel distance of the power tiller ought to be adjusted to be the same as the row distance in order to bury completely all the green manure plants. For instance, when the row distance is 30 cm, the wheel distance of the power tiller should be 30 cm. But if the row distance is 50 cm, and the distance between the wheels can not be adjusted to 50 cm, the latter may be adjusted to 25 cm and half row will be plowed at a time.

3. Comparison of use of power tiller vs cattle in upland field: When using

power tillers in dry fields, the moisture content and the nature of soil have much to do with work efficiency. Results of experiment show that the localities in which the power tiller excelled the cattle are: Taipei, Hsinchu, Tungshih, Taichung, Chiayi, Hualien, and Taitung. The depth of plowing of dry field with power tiller is from 5 to 6 Taiwan inches, the time of plowing each hectare 15 to 23 working hours. The longest working period occurred in Hsinchu, 23 working hours, and the shortest in Hualien, 15 working hours. At all other places, around 20 hours.

In the same localities, the depth of plowing achieved by cattle ranged from 3.8 to 5.5 Taiwan inches, and the time required was 30-50 working hours per hectare. However, there are some exceptions, the Tobacco Research Institute at Taichung reported that the depth achieved by the power tiller was similar to that achieved by the draft cattle, but the time required for the power tiller was 5 hours less than the draft cattle for each hectare.

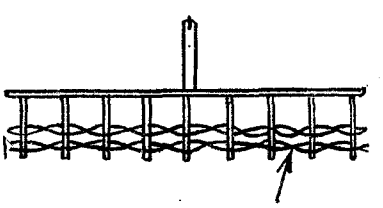
The Tainan District Agricultural Improvement Station and the Tainan Fiber Crops Experiment Station both reported in December, 1956, that the power tillers plowed one half Taiwan inch more in depth than did the draft cattle and used 5-6 working hours more than the cattle for each hectare of land plowed. However, in July 1957, the Tainan District Agricultural Improvement Station again reported that the power tiller could plow a hectare of land in just about the same time as needed by an eight year old yellow cattle, which is 22.5 hours, and the power tiller could go one more inch deeper than yellow cattle (19 cm for power tiller and 15.6 cm for yellow cattle). This certainly indicates that the working efficiency increases when the operator's technique improves. In both reports, the power tiller operator conceded that driving the tillers was more tiresome than driving cattle. The Hsinchu District Agricultural Improvement Station is specially conscious about moisture content of the soil and stated that when the field is too dry, plowing with the power tiller will be quite difficult. As a matter of fact, all the field tests conducted by the Hsinchu Station were carried out when the moisture content was in favorable condition. This is also true in the Pingtung area. Power tillers are more sensitive in dry fields to the soil texture than in paddy fields and the results obtained vary wide.

(2) **Breaking, pulverizing and levelling soil:** Using power tillers to break up, pulverize and level the plowed dry fields involves the same kind of tools and methods as in preparation of paddy field, and therefore they are not repeated here. Mr. Peng Tien-sung made the following suggestions regarding selection

of farm tools for use on fields of special conditions:

1. On heavy clayey soil: After being plowed the dry field will have large clods, which should be broken up by breaking rotor. Attention should be directed to the moisture content. The rotor blades should be arranged to make the blades parallelly curved. The distance between the rotors should be arranged to the largest extent to prevent soil clod from accumulating in-between them and making the rotors a solid ball, which reduces the work efficiency greatly.

2. On sandy soil: Breaking rotor may be used for breaking and pulverizing as explained before. Cage shape wheels may also be used for such purpose on the plowed fields. Spike harrow may be attached to the universal hitch for levelling land. If bamboo strips are placed to fill up the spaces between teeth of the spike harrow (pic. 16), the earth moving ability of the harrow may be increased. When using cage shape wheels, put the earth digging side of its bracing blade in the forward direction for better breaking and pulverizing effect. When the soil is too loose, the earth contacting side of the bracing blades should be put to the forward direction to prevent the wheels from bogging down and to increase friction.



Pic. 16.

3. In grassy fields: In fields with a great deal of long grass, secondary land preparation with breaking rotor should not be done until the grass has considerably decayed. This will prevent the grass from entagling in the axle of the wheels and rendering cultivation difficulties.

According to the results obtained by various experiment stations, the breaking and pulverizing job done by power tillers is at about the same speed as by cattle, and if at all faster, only by two or three hours. Soil thus prepared will be in finer granular form and a greater depth will also be reached than when done by cattle. But when its ability on levelling of dry field is considered, the teeth of its spike harrow were found to be too short and not sharp enough for good penetration and the cross-section of the teeth was square in shape which did not facilitate forward moving (teeth with cross-section in oval or diamond shape will be more desirable). Furthermore, the total weight of this small

power tiller is rather light, this is one of its short comings when not properly balanced (as usual heavier machine can work better on breaking, pulverizing and levelling job). The Chien Chang Iron Works of Taichung manufactured a power tiller more or less after the model of Merry Tiller while altering its implement. For instance, the spike harrow is modified to conform to the shape of the conventional animal drawn comb harrow, which fit the local needs much better; the moldbaord of its reversible plow has also been modified and can turn furrow slice better than the original Merry Tiller's. We hope that all power tiller manufacturers will make effort to improve their products instead of copying any specific models.

(3) Crop planting operations:

1. Opening furrow for seeding wheat and planting jute: The Seed & Seedling Multiplication Station in Tung-shih used power tiller with middle buster to open shallow furrows for wheat seeding on well prepared fields. 11-12 working hours were needed for each hectare, as compared to 17-18 hours by cattle. The operators considered power tillers easier to work with than cattle. These shallow furrow can also be used for planting peanuts. Covering the seeded furrow with power tiller and spike harrow has about the same efficiency as when done by cattle with knife tooth harrow. Although the cattle travels more slowly, the width of the knife-tooth harrow is almost double that of the spike harrow attached to the power tiller. For this reason too, the power tiller should have an attachment similar to the knife-tooth harrow not only to facilitate covering the seeding furrows but to meet the general need for land levelling.

The Tainan District Agricultural Improvement Station have used the power tiller and middle-buster for opening jute planting furrows. The power tiller can make furrow 15 cm deep at 5 hours per hectare. When 8 years old cattle (the best age for cattle) is used, the furrow will be 12.7 cm and it takes 7.5 hours for each hectare. The result is considered very satisfactory.

2. Direct preparation of field for wheat seeding: Direct preparation of wheat seed bed means the use of cultivator for crude land preparation right after the harvest of the second rice crop without previous plowing. According to the Taichung District Agricultural Improvement Station which used the power tiller with pipe wheel and cultivator, the effective width and depth achieved by the power tiller and that by cattle was the same or similar. But the soil is of in much better granular form, making it more suitable for wheat to grow than when done by cattle. The time needed for the power tiller was seven hours

per hectare, which is 3 hours less than using the cattle. Making ridges with power tiller and middle buster on such directly prepared field will also take 7 hours, when using cattle 10 hours are necessary. The work performance and efficiency are both satisfactory. The Taichung District Agricultural Improvement Station also suggested to make the cultivator a three row type (add one set of cultivating tool behind each of the two wheels). This will augment the work efficiency 2 to 3 times.

3. Build high ridges for planting sweet potato vines: This is not an easy job for power tillers. Mr. Peng Tien-sung suggests using of steel lug wheel and reversible plow to build ridges according to following procedures:

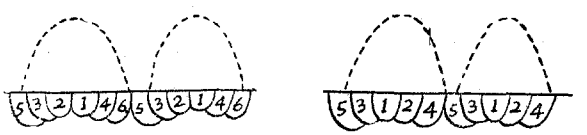
a. Adjust the moldboard turning lever of the reversible plow to the lowest position, and screw tight to increase the plow's furrow slice turning ability.

b. Move the moldboard curvature adjusting lever to the foremost position, and screw tight to make the steepest angle to increase the plow's furrow slice lift-up ability.

c. Put steel lug wheel in the innermost hole of the axle. Start work when the moisture content of soil is just right.

d. Adjust the depth of plowing to around 5 Taiwan inches, and use balance weight accordingly.

e. Plow the first and the second adjacent rows closely, turn the furrow slices toward each other. and travel at the lowest speed. Plow once or twice more along both sides of the primitive ridges to hill up soil (pic. 17). Travel



Clayey soil Sandy soil

Pic. 17.

speed for these later trips ought to be higher. If the power tiller is equipped with a plow position shifter in the universal hitch the position of the plow should be shifted every time so that the distance between the land to be plowed and the position of the wheels will coordinate well to facilitate the work. In actual practice, however, the Merry Tiller we tested, as well as any other power tillers, is not suitable for hilling up high ridges. Becauses the land clearance of the power tillers is limited, it can not be adjusted to have as much clearance as the belly of a cattle from the ground. Although the distance between the wheels can be adjusted, the wheels have to be on both

sides of the power tiller and can not be narrowed to the distance between the right and left limbs of a cattle which almost step on one line. The wheels of the power tiller sometimes have to ride on the just-hilled-up ridges and will destroy it right way. Therefore the procedures explained above will only build medium ridges not really as high as the conventional ridges. It may be profitable to study in the future how to plant sweet potatoes on the low ridges made by power tiller and see what the result will be. We can not expect the same mximum advantage if we use the power tiller in the same way as we use cattle.

4. Build ridges for planting sugarcane and cultivate ratoon canes: High ridges are customarily made for sugarcane planting in Taiwan just as in sweet potato planting. The Seed & Seeding Multiplication Station used the Merry Tiller and the reversible plow to build sugarcane ridges. Ridges were formed after plowing twice when turning farrow slices to each other. At the third trip of plowing, however, one of the wheels was in the furrow and the other one on the ridge. The ridge just made was therefore destroyed by the wheel. The same thing happened at the fourth time. The operation of the power tiller was rendered therefore more difficult in the last two trips. In terms of working hours per hectare, however, the power tiller had the advantage, using only 11 hours while the cattle took 26-27 hours. The Seed & Seedling Multiplication Station also tried using power tiller to cultivate the sugarcane ratoon field. The speed when using power tiller was about the same as that when using cattle, i. e. 15-16 hours. But with power tiller, the two wheels would be respectively at the bottom of the furrow and over the top of the ridge. Since the ridges in the sugarcane field are quite tall, oftentimes the plow was suspended in between the ridge and the furrow and could not reach the soil at all, besides the difficulty in driving. In the mechanized sugarcane plantations in Negros Occidental Province and Cebu Province of the Philippines, the author saw that they did not make high ridges at all, and the above mentioned difficulties did not occur. The Taiwan Sugar Corporation owned mechanized sugarcane plantation is now following this practice. The results of their experiments will serve as good reference when we employ small power tillers to help planting sugarcane.

(4) Using power tillers for field work in crop growing season:

1. Plowing and hilling tea plantations: The Hsinchu District Agricultural Improvement Station used the power tiller and the reversible plow in tea plantations of the typical red earth for plowing and hilling. 13 working hours

were required per hectare, while the same work would require 40 hours by cattle. The depth of plowing achieved was 5.5 Taiwan inches versus 4 Taiwan inches by cattle. The result was quite satisfactory.

2. Plowing citrus orchards:

As low pruning is generally done in citrus orchards in Taiwan to facilitate pest control and fruit picking, it leaves practically no space for cattle to go in. The Hsinchu District Agricultural Improvement Station tried using the Merry Tiller to plow citrus orchards and found that it could be very easily operated and maneuvered. Only 11 working hours were required for plowing each hectare and the depth averaged 5 inches, to the great delight of the farmers. The Fengshan Sub-tropical Horticultural Experiment Station also tried plowing with power tiller and found it faster and more economical than cattle as only 16-17 working hours per hectare were required and the depth achieved was also 5 inches.

3. Intertilling, weeding and hilling in cotton fields:

The Tainan Fiber Crops Experiment Station used the breaking rotor for intertilling and weeding in cotton fields. When done by human labor, the work used to take 125 man hours per hectare. When using power tiller, which could only work between rows, it took about 10 working hours per hectare. The weeds between the plants still had to be removed by hand and that took 60 working hours. In other words. 10 hours of intertilling work by a power tiller in cotton field equalled 65 working hours by human labors. As the cotton plants are low, the power tiller can not reach close to the roots and therefore can not perform the hilling work.

4. Intertilling in sweet potato nursery:

The Chiayi Agricultural Experiment Station of TARI used power tiller, equipped with breaking rotor, for intertilling in the sweet potato nursery and the result was satisfactory. The time needed was 21-22 working hours.

5. Intertilling in corn field:

Intertilling of corn field is usually done by human labor about 80 working hours per hectare is needed. The Tainan District Agricultural Improvement Station used the Merry Tiller and cultivator, and did the same job at the rate of six hours a hectare, which is $^1/_{13}$ the time needed by human labor.

6. Intertilling in peanut fields: The Tainan District Agricultural Improvement Station reported that this work could not possibly be done with power

tiller as the average distance between rows of peanuts are 40 cm, which is exceeded by the smallest between-wheel distance of the Merry Tiller. This means the tiller cannot travel in one row, and the largest between, wheel distance done not allow the machine to stride over two rows (Just striding one row is of no use, because the single row cultivator will sit right on top of the peanut plants). However, the Hualien District Agricultural Improvement Station considers it feasible to use power tillers in the peanut fields, as in the east coast wider row distance in peanut planting is adopted. The Hwalien Station believes that shortening of between-row distance is not advisable if we want to use the power tiller but suggests that the distance between plants may be shortened to make the total number of plants in an unit area remain unchanged.

7. First intertilling and weeding after transplanting of tobacco:

These work used to be done with cattle and animal drawn cultivator. The Tobacco Research Institute tried to do this job with power tiller and its allied cultivator. The Institute found the power tiller could do the work at double the speed of the cattle. However, the soil clods were larger when using power tiller than using animal drawn cultivator, as the power tiller's cultivator has fewer teeth than the conventional animal drawn cultivator. If the number of teeth of the power tiller's cultivator can be increased, it will be a good substitute for its conventional counterpart. When the tobacco plants grow to a certain height, the second hilling has to be done by hand, as the power tillers are liable to hurt the tobacco leaves.

(5) Using power tillers for some harvesting job:

The Seed & Seedling Multiplication Station have tried using the power tiller and the reversible plow to dig up the sweet potatoes. First, the sides of the ridges were plowed to remove soils, then the power tiller was driven astride the ridges, breaking up the center of the ridge and exposing the sweet potatoes. The first two side plowings are considered all right though the power tiller itself will be tilted and is rather hard to operate. For the third plowing i. e. the ridge breaking operation, however, the ground clearance of the power tiller appears to be too low and the chain case usually got caught on the top of the ridge and could not move at all. Therefore, only by using larger wheels on the power tiller could this difficulty be overcome.

V. Trail Use of Power Tillers for Various Stationary Work and Transportation Job on the Farm.

The Merry Tiller is equipped with pulley type power-take-off which makes it possible to transmit, via the belts, the engine power to various machines as their prime mover. The trial use conducted by the TARI included rice threshing machines, sweet potato slicing machines and ramie decorticating machines. The PFA Farm Machinery Manufactory in Taipei, and the Chien Chang Iron works in Taichung have all tried on the small centrifugal pump and Chien Chang and Yung An on power spraying unit, they all consider it very successful. If all the farm machines in rural Taiwan that are propelled by hand or foot, such as winnower, straw rope machine, forage cutter, etc can be propelled with power from the power tiller, the number of working hours of the power tiller in a year will be greatly augmented. The Merry Tillers come equipped with trailers, which have been imported for demonstration by the PFA. However, the Merry Tillers imported by PFA for sale to the farmers are not equipped with trailers in consideration of the buying power of farmers. In actual use, we find the trailers, as light means of transportation, are quite useful to farmers in moving their farm produces and fertilizers etc in between villages and towns. The wheels used for field jobs can not be used on the roads, they will need a helper to carry the field wheels and all the farm tools to and from the fields every day if they do not have a trailer. This would be a waste of man power. The Taitung District Agricultural Improvement Station and the Fengshan Horticultural Experiment Station each made a simple trailer for transportation and found it to be quite helpful. Therefore the JCRR have purchased trailers and road wheels for all the power tillers in use in these agricultural experiment stations and agricultural school for their own use and for showing to the farmers.

VI. Is it Economical for Farmers to Use Power Tillers in Taiwan?

In the previous sections we reported on the capacity and work efficiency of the power tiller tested. As agricultural production is an economic enterprise, we should also inquire into the economy of the use of power tillers. The 13 experiment stations have studied the economy of the use of power tillers along with the tests. Following is a table of the operation cost of the power tillers for various field jobs in comparison with cattle:

Comparison of Costs of Field Operations Performed by Power Tillers and by Cattle

Field Operations	Cost when using Power Tiller (NT$/ha.)	Cost when using Cattle (NT$/ha.)	Experiment Station
Plowing paddy field (heavy soil) (once only)	198.00	130.00	TARI
Breaking and pulverizing paddy field (once only)	84.00	130.00	TARI
Harrowing paddy field (once only)	17.00	40.00	TARI
Plowing paddy field	190.00	270.00	Hsinchu Agricultural Imp. Station
Harrowing and leveling paddy field	116.00	420.00	Hsinchu Agricultural Imp. Station
Plowing paddy field	132.00	200.00	Kaohsiung Agricultural Imp. Station
Harrowing and leveling paddy field	132.00	120.00	Kaohsiung Agricultural Imp. Station
Plowing paddy field (Sandy loam)	162.00	270.00	Taitung Agricultural Imp. Station
Complete preparation of paddy field (including plowing, harrowing, etc.)	270.00	500.00	Hualien Agricultural Imp. Station
Complete preparation of paddy field (including one plowing, two pulverizing and two harrowing)	320.00	640.00	Taichung Agricultural Imp. Station
Complete land preparation for 1st rice crop (including plowing, harrowing, leveling, etc.)	711.00	1,100.00	Taipei Agricultural Imp. Station
Complete land preparation for 2nd rice crep (including plowing, harrowing, etc.)	336.00	600.00	Taipei Agricultural Imp. Station
Plowing dry field (heavy soil)	170.00	130.00	TARI
Plowing dry field (sandy soil)	145.00	168.00	Tainan Agricultural Imp. Station
Secondary preparation of dry field (sandy soil)	73.00	85.00	Tainan Agricultural Imp. Station
Plowing dry field (sandy soil)	107.00	250.00	Tainan Fiber Crops Experiment Station
Harrowing dry field (sandy soil)	42.00	42.00	Tainan Fiber Crops Experiment Station
Plowing dry field	87.50	102.80	Fengshan Hort. Expt. Station
Harrowing dry field	51.50	64.25	Fengshan Hort. Expt. Station
Plowing dry field	158.00	200.00	Kaohsiung Agricultural Imp. Station
Pulverizing soil on dry field	158.00	120.00	Kaohsiung Agricultural Imp. Station
Plowing dry field	112.50	120.00	Seed & Seedling Multiplication Station
Breaking clod in plowed dry field	63.00	—	Seed & Seedling Multiplication Station
Harrowing dry field	77.20	60.00	Seed & Seedling Multiplication Station
Plowing dry field	132.10	—	Chiayi Agricultural Expt. Station
Plowing dry field (sandy loam)	152.00	160.00	Taitung Agricultural Improvement Station
Complete preparation of upland field (including one plowing, two pulverizing and two harrowjng)	550.00	660.00	Taichung Agricultural Imp. Station
Plowing tea garden	93.60	172.00	Hsinchu Agricultural Imp. Station
Plowing citrus orchard	77.60	172.00	Hsinchu Agricultural Imp. Station
Making ridges in sweet potato fields	160.00	78.00	Tainan Agricultural Imp. Station
Making ridges for planting sugarcane	90.00	—	Seed & Seedling Multiplication Station
Opening furrows for planting jute	57.50	73.50	Tainan Agricultural Imp. Station
Opening furrows for planting wheat	59.00	—	Seed & Seedling Multiplication Station
Weeding in cotton fields	51.00 (Partly by man)	92.80 (All by man)	Tainan Fiber Crops Experiment Station
Intertilling upland crops	88.30	—	Chiayi Agricultural Expt. Station
Intertilling corn fields	112.00	195.00 (All by man)	Tainan Agricultural Imp. Station

From the above table we can see that the cost estimates made by the various stations differ a great deal. Although the overall tendency is that the use of power tillers is more economical than cattle, but there are instances when the use of power tiller were uneconomical. The technical reasons for these instances have been discussed in the foregoing sections. These data, though indicative, can not be considered as completely dependable. Some errors and deviations are inevitable and I believe they are due to the following reasons:

(1) The experiment stations were so enthusiastic to start the tests that they could not wait tor government allocation of fuel at ration prices, as this would take quite few month and the plowing season would be over. Instead they bought the fuel in the market. Therefore the cost estimates were made according to the higher market prices of fuel they paid. Also gasoline sold in the market is not infrequently mixed with foreign matters by merchants causing unnecessary increase in fuel consumption. These all caused increase of fuel cost in operation of power tillers.

(2) There is as yet no accurate and standardized calculation on the cost for keeping a cattle in the farm and the daily cost on use of cattle for field work. Therefore it is very difficult to accurately compare the cost of use of cattle and that of power tillers.

(3) The present method of using the power tiller is to do it in the same manner as the cattle works. This gives the power tillers no opportunity to work with their maximum efficiency. Furthermore, the operators of these power tillers had but just finished training and their skill and ability on utilization of the power tiller was not uniform and left much to be desired.

(4) When calculating the cost of operation of both the cattle and the power tillers, most experiment stations failed to figure the depreciation and maintenance costs of the power tiller and the annual up keep cost for the cattle, (The service life of power tiller is limited. It needs greases, lubrication, repair. On the other hand service life of a cattle is also limited and the cattle needs feed care and medical attention the year round, whether it is working or not.) Therefore some of the costs listed in above table do not represent the actual cost.

(5) The figure on cost of operation reported were derived from small areas and in short period of time. Therefore they represent only the cost under the situation where the test took place for that particular time. Long range field test in more places are needed to suppplement, amend, or support such data.

(6) Each of the field operation was undertaken separately not systematically conducted throughout the whole growing period for each crop by natural

sequence of of plant growth. Therefore the results do not indicate the overall effects on the use of power tillers on the crop yield, and hence do not form the basis for rendering adequate judgement of the advantages and disadvantages of using power tillers.

Although the numerical data can not be relied upon to calculate the economic value of the power tillers, but we can figure the theoretical cost of the use of power tiller. It is the number of hours of service that a power tiller may render to the farmer per year that have the most important effect on the economy of use of power tillers. The more working hours in a year, the smaller is the per working hours cost. This is illustrated in the following formula:

$$Cu = Fc/x + Oc$$

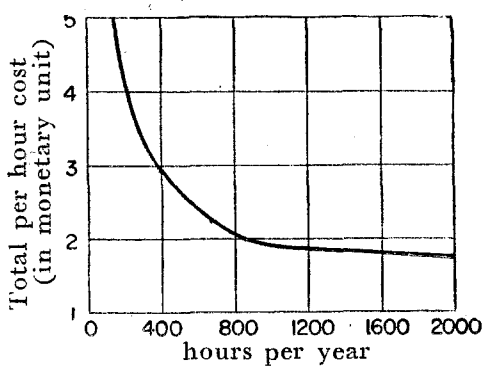
Cu—total per hour cost of use of power tiller

Fc—annual fixed cost of owning of power tiller

x—working hours of power tiller per year

Oc—operating cost of power tiller per working hour

the above formula may be experssed in grahphic form (picture 18)



Pic. 18. Effect of use on unit cost of operation of power tillers

From the above chart we can conclude that the use of a power tiller is economical only when it is used over for 800 hours or more in a year. The overall average of use of tractors in the United States farms is 592 hours, it is not uncommon for the general purpose tractors to working up to 800 hours and some times as high as 1,500 hours in a year. This is one of the reasons that the general purpose tractor has become more and more popular on the U.S. farms. The Taiwan Sugar Corporation strongly advocated increase of the total annual working hours of its tractors. At present the average of working hours of TSC tractors has reached 1,200 a year. Therefore our suggestion on 1000 hours per year for small power tillers is quite reasonable.

The Fc factor (fixed cost) in above formula includes the following items:

1. Depreciation of machine—If the power tiller sells for NT$12,000 each and its service life is 6 years (This is an arbitary but conservative figure, proper maintenance and timely repair will lengthen the service life greatly.) By using the simple straight line method on figuring, its depreciation will be NT$2,000 per year.

2. Interest on investment: At the prevailing interest rate of 15% per annum, the interest on investment will be NT$1,800 a year.

3. Tax, insurance, storage costs, etc. 1.5% of the purchase price, i.e. NT$ 180 a year.

4. Repair lubrication, and regular maintenance: 5% of the purchase price, i.e. NT$600 per year. (In Chinese text of this paper, 2% was used, which was adopted from an investigation made on the actual repair and maintenance cost of power sprayers, diesel engine powered pumps and motorcycles used in rural Taiwan. As the power tiller comes to Taiwan only very recently, no actual and reliable estimate could be made yet. After release of the Chinese text, people commented that 2% was too low. the rate 5% is now adopted from U.S. general average in tractors. This is also suggested to the author by Mr. Fernando A. Santiago Chairman of the Agricultural Tenancy Commission of the Philippines as this figure is also used in that country. We hope we can have our own figure some day to replace these arbitary figures.)

The Oc factor(operating cost) in the above fromula includes the followings:

1. Fuel: The Merry Tiller consumes an average of 0.2 gallon of gasoline per hour priced at NT$14.00 per gallon.

2. Lubricant, grease, etc.: hourly consumption equivalent to NT$0.10.

3. Operator's wages: NT$20.00 per day, 8 hours a day, the hourly wage is NT$2.50. (Wage is also a mooted item. One can hardly hire a casual labor for less than NT$25.00/day and sometimes as high as N.T.$30/day. But the long-term hired help on the farm can seldom get more than NT$450/month including board. Therefore, we still use NT$20 day here.)

If the Merry Tiller is being used 1,000 hours a year, the total per hour cost will be:

$$Cu = \frac{12000 \times (16.7\% + 15\% + 1.5\%)}{1{,}000} + (2.8 + 0.1 + 2.5) = \text{NT\$9.98}$$

To plow one hectare of paddy field with a power tiller requires about 20 hours, the cost will be about N.T.$200.00 (NT$9.98x20=NT$199.60). It is very

difficult to compare this with the cost of plowing paddy field with baffalo, as the method of calculating the latter cost is not yet standardized. However. if we take the buffalo custom plowing cost for comparison the plowing with power tiller is very advantageous, as the current rate for one plowing is ranging from NT$250 to NT$300 per hectare. Moreover, the farmers who bought the power tillers have all learned to drive the power tillers themselves and did not have to pay cash for wages. In the busy seasons farmers do not have to hire short period workers and buffaloes to help as the higher efficiency of the power tillers may help the farmers safely over the peak labor demand period, and much casul wages may therefore be saved. For these reasons the advantage of the use of power tiller over the cattle may be even higher than that indicated in the above table. However, if the annual working hour of the power tillers is shortened, the situation will be changed.

How much work can a power tiller do on a typical three-crop-a-year farm of one hectare in area? This is roughly estimated as follows:

For 1st rice crops: Plowing: 20-25 hours
Breaking clods, pulverizing, and levelling soil: 20-30 hrs.
Field spraying: 10-15 hrs.
Driving the rice threshing machine: 16-20 hrs.
Transporting farm produces, fertilizers etc.: 40-50 hrs.
Sub-total: 106-140 hrs.

2nd rice crop: About the same as mentioned above.
Sub-total: 106-140 hrs.

Winter crop: Plowing: 20-30 hrs.
Pulverizing and levelling soil: 20-30 hrs.
Intertilling and weeding: 15-20 hrs.
Transporting farm produces, fertilizers, etc.: 40-50 hrs.
Sub-total: 95-130 hrs.

Total working hours in a year: 307-410 hrs.

From the above rough estimates we find that only on a piece of land of 2.5 to 3 ha. can a power tiller such as Merry Tiller be economically utilized. But if after due development, more work is done on the farm with the power tiller, the suggested area of economic utilization may be reduced. As to the cost of the power tiller, most people think the present price of the Merry Tiller NT$12,000/unit. is too high. The local manufacturers expressed that they could supply as good power tillers with choice of 2.5HP or 3.5HP engine

within the price range of NT$8,000-10,000. The author is making the cost estimates on the basis of NT$12,000 because even if the price of power tiller is lowered, the farmers still have to purchase more attachments such as trailers spraying unit etc. for the above mentioned jobs and therefore the eventual cost of a power tiller and all necessary attachments will still be around NT$12,000.

VII. Discussion on the Power Tiller Ownership:

In recent years more and more countries are using tractors for agricultural production. The ways of owning the tractors, however, differ according to the farmer's purchasing power and size of his farm. In general, there are four ways: (1) Individual ownership and for use in his own farm, (2) Owned by an organization, a group or a profit-making entity to work for farmers at cost plus basis. (3) Partner ownership and cooperative use, and (4) Individual ownership, and, when possible, working for others for a fee. Each of the four ways has its merits and shortcomings which we shall compare and discuss briefly in the following:

(1) Individual ownership and for use in his own farm:

a. Merits: i. He will adjust, and modify the attached farm tools, and get the maximum efficiency out of the power tiller. ii. The owner will constantly and strenuously study the ways to utilize the power tiller in his farm. This will greatly extend the working scope of the power tiller in his farm. iii. He will be attentive to the proper maintenance and repair of the power tiller.

b. Shortcomings: When the owner's farm is not big enough to keep the power tiller working up to the minimum economic annual working hours, i.e. 1000 hours/year, investment made on the power tiller will become uneconomical.

(2) Owned by an organization or group to offer custom service to farmers at cost plus basis:

a. Merits: i. The working capacity of the power tiller will be fully utilized. ii. Farmers who can not afford to buy a power tiller will also have an opportunity to use it.

b. Shortcomings: i. Unless the farmers really can not do the field work with his own cattle, they will not hire custom service and pay the fee. This will practically eliminate the use of power tiller for work on the farm other than during the very busy seasons, and will retard the all-phased mechanization of agriculture. ii. As the farmers only seek help from power tiller during busy seasons, they will have to have some sources of power for other times.

Therefore they still have to keep a draft cattle. Part of the work done by cattle is now given to the use of custom service of power tillers. Therfore, the farmers not only have to pay for the use of power tillers, but the working hours of the cattle are reduced. These constitute a two-sided uneconomy from the farm management point of view.

(3) **Partner ownership and cooperative use:**

a. Merits: i. Farmers who do not have sufficient money to buy a power tiller individually may pool their funds together and all enjoy the use of power tiller. ii. The working capacity of the power tiller will be fully utilized.

b. Shortcomings: i. Every owner has equal right in use of the power tiller. During busy seasons it becomes difficult to make the power tiller available to all the owners satisfactorily. ii. None of the owners will pay attention to the proper repair and maintenance of the power tiller.

(4) **Individual ownership and work for others for fee at leisure time:**

a. Merits: i. Work schedule will be well-arranged by owner according to priority, and the working capacity of the power tiller is fully utilized. ii. The owner will pay attention to the maintenance and repair of the power tiller.

b. Shortcoming: Individual ownership may delay the adoption of power tillers in the low affordability level in the rural area. It is much easier for several farmers to purchase a power tiller jointly than for a single farmer to amass the funds for the purchase.

Based on above comparison and analysis, we think that if an individual can afford to buy a power tiller (either he has the money or can borrow at a reasonable interest rate), it is best for him to buy one for his own use. If the area of his farm is limited and can not utilize the power tiller fully (i.e. the power tiller is not operated up to 1,000 hours a year), he can take job assignments from neighbours for a fee. If the individual does not have or cannot raise the money to buy a power tiller, he can pool his funds with his friends for purchase of a power tiller. But the number of partners in this case should not be too many. In France, for instance, where the farm holdings are small according to European standard, the French Government has decreed in their cooperative regulations that the cooperative owner-users of a tractor should not be less than five persons. The result is that these owner-users do not always agree with each other and have to abandon the cooperate way. In Germany, where farmers also have small holdings, cooperative use of tractors is also urged, especially after the second World War. The findings of specialists in

agricultural machinery and farm management after careful on-the-spot surveys and studies show that the ideal number of cooperative owner-users of a tractor should be no more than two. The same should be true in regard to the cooperative or joint owning and using of power tillers in Taiwan. As we have mentioned before, small power tillers can be effectively used over 2.5-3.0 ha. of land. Therefore if two to three persons have a total farm area of 2.5-3.0 ha. a small power tiller may be very efficiently used in the small group coopertively. However, large scale cooperative use of power tillers or power tiller custom service teams are considered impractical in Taiwan.

The above includes only discussions on the ownership and ways on utilization of power tillers. In regard to the power tiller itself and the attached farm implements, we may elaborate as follows:

1. Essential Machines and attachments to be owned by individual owners:

a. Necessary machinery and attachments—the following items are suggested for all power tiller owners.

i. The tiller body and the engine.

ii. Plow, and wheels needed for plowing in paddy and dry fields (if a farmer has only one kind of field, only one type of field working wheels needs to be bought).

iii. Harrow (different kinds, preferably those that can be used both on dry land and in paddy fields).

iv. Trailer and tiller wheels used for driving on roads.

b. Optional attachments:— to suit the individual needs of the power tiller owner for the specific crops he raises.

i. cage shape wheels
ii. middle buster
iii. various types of breaking rotor
iv. power-take-off
v. mower

2. Equipment and attachment may better be owned and used jointly: Machines which are more expensive and can only be used for a relatively short period in a year may be more suitable for joint purchase and use by rotation among several farmers. Spraying unit that use P. T. O. of the engine of the power tiller is one of the typical example of this group. The small harvester that may be developed in the future, will also belong to this group.

3. Machines may better be made available to farmers on custom service

basis: These are more expensive machines of complicated structure and needed at infrequent intervals. They are almost impossible for individual farmers to own and to maintain. They should be owned by custom servicing organizations. Such machines include the combine harvester, the big crawler tractors and allied bulldozer and subsoiler, and equipment for making countours and terraces on slope land. Of course these types of work exceed the scope of work that small power tiller can do. But it is an important part of the agricultural mechanization ring, and therefore, we should not neglect them. The above are suggestions to farmers on their starting stage of planning of use of farm machineries. They also, may serve as reference to farm machinery manufacturers in producing machine and approching their customers accordingly.

VIII. Ideal Power Tiller for Taiwan

It is impossible for us to treat the subject at length here from the purely engineering point of view. But it will be discussed briefly for the benefit and reference of farmers especially when they are selecting power tillers. The author hopes these suggestions can also help the manufacturers to develop a rough blue-print in producing power tiller suitable for use in Taiwan.

(1) Types.

According to the operator's operating position, we can divide the power tillers into the riding type and the walking type; according to the ground drive components of the power tillers, we can divide the power tillers into the wheel type and the track-layer type. As the riding type small power tillers consume too much power and are not convenient for use in small fields and the track layer type tillers are complicated and incur more repair and maintenance expenses, we do not suggesting adopting them in Taiwan. Therefore only the operator walking wheel type power tiller will be discussed here. The operator walking wheel type of power tillers may again be divided into three types.

1. Tractive type:

This type of power tillers should be correctly named as garden tractor. It pulls various farm implements, such as plows, harrows, cultivators and trailers. The only difference from the usual field tractors is that the operator has to walk while working. Typical examples of this type of power tillers are the Planet Junior garden tractor and the Bolen Power-Ho garden tractor imported by JCRR from the United States and also the hand tractor manufactured by the Mitsubishi Heavy Industries Co. Ltd., imported for trial use by its local

agent. These power tillers are all built with good engineering and good craftmanship but only suitable for use on dry fields (the Japanese made one may be used on paddy field), and the prices are much too high for Taiwan farmers.

2. Driven type:

This type of power tillers was developed and produced solely in Japan. Power tillers of this type may again be devided into three different types according to their working tools, i. e. the rotary type power tiller (such as the Kubota power tiller), the crank type power tiller (such as the Yamasa power tiller), and the screw type power tiller (such as the Furukawa power tiller). The two later types of power tillers are equipped with track laying ground driving device and are suitable only on the deep-mud paddy field. Therefore, their uses is limited. The rotary type power tiller is the predominant type up till now and is produced by no less than some 30 manufactories in Japan, among which some have been imported to Taiwan; the most important ones are Kubota, Iseki, etc. The Kubota power tiller the PFA purchased with JCRR subsidy and later sold to farmer Wu Pu-chao of Yuanlin Chen, Chang-hwn Hsien, and the power tiller used by Mr. You Shui-teh of Tashu Hsiang, Kaohsiung Hsien, both belong to this type. Mr. Wu and Mr. You expressed satisfaction over the work efficiency of their power tillers. However, they think their power tillers are bulky and heavy, difficult for travelling on the narrow footpaths in rural paddy areas. Furthermore this type of power tillers do not have plow and intertilling implements, therefore can only do the land preparation work with rotary tools, but not any other field work after the crop is seeded. The author wishes to report that when he visited the Kanto-Tosan Agricultural Experiment Station in Japan, Mr. H. Kaburaki, Chief of the Agricultural Machinery Division told him that in the first one or two years of using the rotary type power tiller, the depth of land tilled increased and so did the crop production. But when used continously for three or more years on the same field, the rotary tilling equipment could not invert the sub soil to the top or vice versa, hence crop production tended to decrease. Mr. Kaburaki thinks that the plow is an important and necessary implement no matter what kind of power is employed in the farm. This point has been confirmed by the Japanese Ministry of Agriculture and Forestry in its publication entitled "Agricultural Equipment and Machinery in Japan," although the experiment results were not published. Mr. Yueh Chin-tung, Chief of Agronomy Division of the Taichung District Agricultural Improvement Station, who recently returned from a trip to Japan, said that after using large power tillers in Japan, the soil in many places has

become degenerated due to insufficient weathering. Therefore, large power tillers are gradually replaced by small power tillers. The large power tillers mentioned by Mr. Yueh are not the Western type large tractors but the driven type power tillers that are not equipped with plows. The small power tillers mentioned by Mr. Yueh indicate the tractive and rotary type power tillers which we are experimenting with.

3. Tractive and Rotary Type:

In the United States, a rotary tiller that carrys the "travel with working tool" idea is developed in recent years. This type of power tiller is originally not equipped with wheels, but with rotary tilling tools on the axles where the wheels are usually placed. When the tiller works, its rotary working tool will also serve as wheels to carry the tiller foward. This idea is considered an improvement because it reduces the slippage that usually happens while travelling with wheels and thereby increases the efficiency of the power tiller. The manufacturer that produces this type of power tiller is the Merry Manufacturing Company of Edmond, Washington, and the product is named the Merry Tiller. When this idea came to Japan, it was again modified, and a tractive and rotary power tiller is developed. This is a combination of the tractive type graden tractor and the "travel with working tool" type power tiller. It can be equipped with wheels to pull all farm implements or it can do without wheels and be equipped with the rotary working tools. By using different types of wheels, this power tiller may be used both in paddy fields and in upland fields. The first firm producing this type of power tiller is the Saiosha Iron Works Ltd. of Japan in cooperation with the Merry Manufacturing Company of U. S. Till today, about some 40 manufactories, large or small, are engaged in the manufacturing of light weight tractive and rotary type power tillers and their annual production totaled 50,000 units, although only 14 passed the last Japanese Government tests as officially reported. Power tillers of the tractive and rotary type are light in weight and simple in construction. Therefore their costs of production are lower than those of the previous types. Although they have only come into use in Japan in the recent five years or so, in the Chinese edition, the author reasonably anticipated that it will replace the hitherto most popular driven and rotary type power tillers. By June, 1957 Mr. Kaburaki wrote to the author "In the number of years, as you know, we have used the driven type tractor such as rotary, crank and screw type in our country. In recent years, however, the tractive and rotary type such as the Merry Tiller and the Mametora etc. are rapidly extending

and going to replace the driven type, because the latter can be used for various farming job". This, certainly synchronizes with the author's thinking.

In view of greater year round working ability of the tractive and rotary type power tillers in the farm and their relatively low first cost, as we have discussed in the foregoing paragraph, it is very logical to extend the use of the tractive and rotary type power tillers in the agricultural mechanization program for the average farm holdings in Taiwan.

(2) How Much Power for the Tillers:

Before we launch into the discussion of the subject, let us first examine some reference data:

1. Human force in terms of HP:

i. Work accomplished with utilization of the body weight of the worker:—0.13 HP

ii. Work accomplished with foot to rotate horizontal axle such as operating a pedal dragon pump:—0.09 HP

iii. Work accomplished with hand to rotate vertical axle, such as operating a conventional plate mill:—0.08 HP

iv. Work with up and down movements of lever:—0.07 HP

v. Up and down work such as drawing water from well with water bucket:—0.05 HP

2. The travel speed of the cattle:

i. Native buffalo walking alone:—50 m. per minute

ii. Native buffalo when plowing paddy field:—17-25 m. per minute

iii. Indian cattle (Kankrej and Sindhi) walking alone:—86 m. per minute.

iv. Indian cattle and hybrid cattle (hybrid Sindhi, first generation hybrid of Holstein and yellow cattle, Kankrej and yellow cattle, and Holstein and Sindhi) pulling Takechi type improved plow (depth of plowing 9.5 cm, width of plowing 19.5 cm):—30-50 m. per minute in average.

3. Pulling force of the cattle:

In continuous work, the average pulling force of the cattle is 1/10 to 1/8 of the body weight of the cattle. It may be slightly increased in short working period but should not exceed 1/6 of its body weight by all means. Ordinarily a native buffalo weighs on the average about 400 kgs (female) to 450 kgs (male). Therefore when working all day, the draft should be somewhere

between 40-50 kgs. Hybrid cattle weighs on the average of420 kgs (female) to 610 kgs (male) with draft power from 42-76 kgs. The cattle used by farmers in Taiwan are mostly native breed cattle. And hybrid cattle are usually used in rural transportation.

4. Power consumed for rural work in Taiwan:

As we do not have enough data on this, we shall only cite a few examples:

i. Plow: The draft power of a cattle when plowing the field varies largely with soil texture, which ordinarily is within the range of 50-100 kgs, and the mode is around 60 kgs. That is in average the draft is about 6.3 kg/cm^2 (about 9 psi).

ii. Harrow: Draft is around 30 kgs (i. e., 26 kgs for each meter of working width).

iii. Rice threshing machine: 20-40 kgs, varies with the size of the machine.

From the above data, we can see that the draft power needed for plowing the field is about 60 kg or up, which exceeds the strength of a native buffalo as it is around 40-50 kg. This is the reason why plowing deeper is not possible when using native buffalo in paddy fields.

From the above, also, we can see that the native buffalo produces a power of about 0.3HP While the hybrid buffalo will produce about 0.5 HP when plowing paddy field. These figures show that the power needed for various work in Taiwan now is generally less than 0.5 HP. The Merry Tiller has an engine of 2.5 rated HP. If the mechanical efficiency of the tiller is 70%, the power available on the axle will be 1.75 HP (V belt is used in the transmission system. Therefore the mechanical efficiency is low), and assuming that the tractive efficiency reaches 70%, the DBHP will be 1.23 HP. If the tractive efficiency is 60%, the DBHP will only be 1.05 HP, which, although not much, is still 2 times the power of hybrid cattle and three times of the ordinary cattle in the case of continuous work. However, the drawbar pull produced from this type of power tiller, as tested, is only about 80 kg. To this point we believe is due primarily to its high travel speed. It, though, is not very ideal but is still better than the buffaloes. The Merry Tiller with its 2.5 HP engine should therefore be able theoretically to take care of all the work performed with human or animal power in Taiwan farms. I wish to point out here the essential fact that the human and animal power has a rather wide range of

variation. Much greaters power may be created within a very short time (For instance a draft cattle creates much bigger instantaneous power after it is whipped). These miraculous multiplication of power will never occur when engines are used. Therefore power tillers can only take over continuous work performed by the draft cattle, but not the work performed instantaneously by a draft cattle.

Before we passover this subject, let us discuss a little about the economy on use of power. After an engine is started, there is a lower limit of fuel consumption which does not differ too much if the load is adequate or is very light. If we select a power tiller that can do the peak heavy work on a farm that only happens in a very short time, then the engine power is wasted when performing most of the works of average load. This we call uneconomic use of power. Also, when a farmer buys a power tiller that is only capable of doing very light work, while the heavy work still has to depend on custom service, it also entails uneconomic use of power. It is agreed by all agricultural machinery workers that the power needed for a farm is guaged by the magnitude of plowing work to be done. This is universally adopted to determine the size and working capacity of tractors (or power tillers) needed in the farm. For this reason too, the capacity ot tractors are ordinarily indicated by the number and size of plows they can pull.

In England, Mr. Denys De Saulles while discussing on the subject of "choosing a light tractor", stated "under very favorable canditions—light, well cultivated soil, reasonably free of weeds and grass—a tractor of 1.5 HP, will plow to a maximum depth of about six inches, making quite a neat job. But such a tractor has no reserve of power for dealing with rather more difficult conditions and certainly of little value for serious plowing on the heavier type of soil.·····The cultivation of your soil is the most important job of all and the one to be borne in mind when making your final choice. In engine-power, these smaller machines range from those such as the BMB Cultmate (3.5 HP) down to such light weight jobs as the Anzani motor hoe with engines of 1 HP. Incidentally, some of these small machines have two-stroke engines, unless you are ultra-sensitive to noise, these are satisfactory in every way." This statement agrees with our primary thinking of that the 2.5 HP power tiller ought to be able take care of all the work performed with human or animal power in Taiwan farms of good tilth.

During last April, we sent out a questionnaire jointly with the Taiwan Provincial Department of Agriculture end Forestry to find out the farmers com-

ment and suggestion in regard to power tillers they were using. There were 60 some power tillers in use by then and 90% of them was Merry Tiller users. Our survey report indicates that about 40% of the Merry Tiller users considered the present power (2.5HP) adequate and 60% considend it not enough; some suggested 3HP engine and some suggested 3.5HP engine, only one suggested 4HP engine. This result again supported our foregoing discussion. The author reaffirms his believe that small power tillers ranging from 2.5HP to 3.5HP will be good enough for most of our well cultivated lands. However, he does not deny the necessity of power tillers of larger engine-power say 5HP or so, as they will be needed where heavy soil exists.

Mr. Chang Cheu-shan reported in his recent article, that the Tokyoto Agricultural Experiment Station of Japan has tested the working efficiency of power tillers as compared to draft horse on paddy field preparation. The result may be shown briefly as follows:

. 3HP To-no power tiller (tractive & rotary type): horse = 1.14 : 1.00

7HP Kubota power tiller (driven & rotary type) : horse = 1.25 : 1.00

This result clearly indicates that the working efficiency of power tillers do not increase proportionally with the engine power but the design (i.e. construction, type, etc) has much to do with its efficiency and final performance. We hope farmers are aware of this and be not fascinated merely by the nominal power when selecting a power tiller.

(3) The Total Weight of Power Tiller:

In the foregoing paragraphs. we mentioned the fact that the tractive efficiency of the Merry Tiller is only estimated at 60%, which is considered low. The reasons for this low tractive efficiency are many. Some people tend to attribute the low tractive efficiency to the weight of the power tiller. This is demonstrated by comparing the Kubota (driven and rotary type) power tiller with the Merry Tiller in the same field. It is a point worthy of our attention. When we look into the history of the development of tractors, we know that in the beginning, most people thought that the heavier the tractor the higher would be its tractive efficiency. However, since Mr. Harry Ferguson designed his Ferguson system tractor, this conception was somewhat revised. The Ferguson tractor was developed upon the theory of weight transfer. Mr. Ferguson commented on his new system as "a complete revolution in the application of machanics to the land". He said that "we are told that we must have weight to get traction. That is true in relation to tractors of the ordinery type but our new system of combining the tractor and implement in one unit solves that

problem and the need for excess weight has been eliminated. It costs a lot of money to buy a heavy machine and a lot to drive it over the land. Weight is not so bad on rail or on a road, but when you take the weight on the land it costs heavily in gas or oil to move it because it sinks. For instance you can push a bicycle with the greatest of ease on a hard road but take it into a soft field and you can't ride it at all. Why? Because it sinks. If you dismount, you can push it with your finger because it doesn't sink!" This idea is adopted by many manufactories of medium and small tractors no matter they admit it or not. However it has not received proper attention by the power tillers manufacturers yet. We believe lightness in weight is particularly important for power tillers that will be used on paddy fields, as which provides the softest surface for any machine. This is one of the reason that we suggest light weight power tillers for Taiwan farmers. The present tractive and rotary type Merry Tiller (model MT-3) is a direct derivative of the simple travel with working tool type Merry Tiller. It is apparent that the draft produced from pull of the trailing type farm implements has disturbed its balance while at work. The Japanese manufacturer of course have seen this and added balance weight to the front of the power tiller in order to compensate for the draft and keep the machine balanced. However, they probably neglected that this power tiller is a single axle type of movable machine, the axle is the pivot of the whole balancing system. It will be all right when travel on smooth suface, but on rugged field especially those just plowed up, the power tiller's unstability will reappear. To solve this problem, I believe that Mr. Ferguson's idea of making the power tiller and implement into one rigidly combined unit is a good suggestion, which if properly adopted will increase both the tractive efficiency and stability of the power tiller. This is where the agricultural engineers can do to help with their technical knowledge and wisdom. In view of narrowness of rural roads especially in the paddy area in Taiwan, light in weight and compact in size are very desirable characters for our power tillers. We believe 60 kg or lesss would be the maneuverable and acceptable weight for small power tillers of 2.5-3.5 HP. Excess weight will only consume more of the engine power when it moves around especially on soft surfaced fields.

(4) The Travel Speed for Power Tiller:

We have mentioned serveral times in the foregoing sections that a 2.5HP power tiller ordinarily ought to be able to perform most of the work in rural areas of Taiwan. However, the Merry Tiller is often regarded by the users in Taiwan as not pocessing enough power. In fact there have been instances where

it seemed to be stalled and could not work well especially in heavy fields. This may be due to two reasons: i. slippage of wheels which causes loss of power, ii. too high travel speed and therefore reduced draft power. In the following we shall discuss the travel speed of the power tiller:

According to the experience of tractor designers and users the optimum speeds for varions type of field operations are:

1. 2-2.5 km/hr: for deep plowing of heavy clayey soil, sub-soiling, field spraying. transplant seedlings, etc.
2. 2.5-3 km/hr: plowing heavy soil, weeding inbetween young plants, harvesting grains.
3. 4 km/hr: plowing ordinary soil, and various land preparation operations
4. 5.5. km/hr: drill small grains.
5. 7 km/hr: final harrowing of prepared field and intertilling on light soils.
6. 15 km/hr: light field work such as broadcasting seeds, cutting grasses, etc.

Under listed are the travel speed for some small tractors and power tillers for our reference before we proceed with the discussion:

Model and make	Rated HP	Forward Speeds (km/hr)
Farmall Cub tractor, IHC.	8.89	3.5, 5.1, 10.4
Allis-Chalmer model G tractor	9.59	2.4, 3.6, 5.6, 11.2
Planet Jr. B-8 garden tractor	2.5	2.4, 4.8
Bolen 15 FC Power-Ho garden tractor	2.5	1.6, 4.8
Kubota KL-16 power tiller	4-5	0.95, 1.18, 2.80, 3.42
Mametora power tiller	2.5	0.6, 1.2, 3.0, 6.0, 12.0
Iseki KB-1 power tiller	3-6	1.1, 1.7, 2.4
Merry Tiller MT-3	2.5	4.3, 5.4, 15.0

We can see very apparently from the above table that the lowest speed of Merry Tiller is still much higher than the speed of all other kinds of tractors and power tillers. The insufficient draft power is no doubt caused by such high

speed. The author believes a power tiller should have a lower speed of not more than 3.0/km per hour, so that it can take up some heavier work that the Merry Tiller MT-3 cannot. Many people comment that the Merry Tiller goes too slowly and that is why its efficiency is not high. We know they must be sight seers. If they go and ask a farmer who walks behind the power tiller day in and day out, he will tell them that the power tiller goes too fast for him to follow.

(5) Engine for the Power Tiller:

The center of attention about this problem in Taiwan now is the selection between diesel engine and gasoline engine, because kerosne is practically not available (limited supply at high price). We shall discuss this under the follwing headings:

1. Weight and size of engine:

The driven type power tiller uses water cooling diesel engine which is heavy and bulky. Therefore the width of the chassis and total weight of the power tiller will all be increased. Bulk is considered a great shortcoming for travelling on the narrow country roads and working in between rows of growing crops. This will make the use of such power tiller very much limited.

The gasoline engines now used on the tractive and rotary type power tillers are smaller and lighter. When using this kind of engine, the power tillers are not only easily maneuvered but are also able to participate in much more work during the crop growing season. Therefore, the ideal power tiller needs a light, compact sized engine.

2. Engine cooling method:

All the garden tractors made in U. S. use air cooling engines. The Japanese agricultural machinery manufacturers also clearly indicate that they think the open hopper type water cooling diesel engines they now use on the power tillers require farmers more daily attention and contribute considerably to their inconvenience. Where the power tillers travel on rugged fields, it will slant and pour water out, just at the time and place where clear water will be hard to find for refill. Recently, some Japanese manufacturers are studying the manufacture of light weight small size air cooling diesel engines for use on power tiller. In view of these disadvantage of the present water cooling diesel engine, we hope the power tillers for our farmers' use will be equipped with air cooling engines.

3. Fuel preferred:

Most people are in favour of diesel engines for power tillers or, at the least, kerosene engines to lower the fuel cost. In Taiwan the situation is different, as we have to consider this problem from the view point of availability. Two points in the report on the Petroleum Industry's First Four Year Plan merit our attention: (i) the consumption rate is highest for jet plane fuel (ie kerosene fuel). diesel oil the next, and gasoline again next. (ii) After some additional equipment is installed in the Kaoshiung Refinery of the China Petroleum Corporation, the refining capacity will increase and production of gasoline is now in a position ready for export. When the JCRR and the China Petroleum Corporation negotiated about allocation of fuel for power tillers, the CPC suggested very firmly that use of more diesel engine powered tiller ought to be avoided and promise that gasoline would be adequately supplied in the future.

The above discussions show that in regard to fuel supply, we do not have much choice. Under such circumstances, it is only natural and logical that we ought to adopt the light weight, small size, air cooling gasoline engine for our power tillers.

(6) Wheels of the Power Tillers:

The tractive power of the power tillers comes from the friction produced between the wheels and the ground. Since tractive power is the real working strength of the power tiller, the relationship between the ground surface and the wheels of the power tiller is of first and last importance to the working efficiency of the power tiller. Since the ground surface is beyond our control, we can therefore only adjust the wheel to adapt itself to the ground surfaces. Power tillers used in Taiwan should at least be adaptable to three different kinds of ground surfaces: the paddy field, upland field and hard surface roads. Therefore three different kinds of wheels are needed. Pneumatic rubber tires will be ideal for travelling on roads to ensure comfort. However solid rubber tires should also be provided as alternative to suit the widely varied purchasing power of our farmers. Wheels for dry fields should be so built as to increase its ground gripping ability in order to minimize slippage and therefrom increase tractive efficiency. For the paddy fields, not only should the wheels fulfill the same requirements as for upland fields, but the wheel ground contact surface has to be increased so that the weight of the power tiller will be distributed over a bigger area to prevent bogging down. To achieve these requirements, wheel lugs are of primary importance. The wheels of Merry Tillers are satisfactory in this respect, and the paddy field wheels made by the

Chien Chang Iron Works of Taichung for its Hsing Nung power tiller are even better. Between wheel space should be arranged according to the distance between crop rows so that the power tiller can go in the field in the crop growing season to do works such as intertilling, weeding, spraying of insecticides and top dressing of fertilizers. However, we wish to point out to the power tiller users that the size of the wheels to be mounted on a small power tiller can not be so increased as to make the power tiller's ground clearance as much as the clearance from the belly of a cattle to the ground. Also, the between wheel distance can not be reduced as narrow as the distance between the hoofs of a cattle when it walks in the fields. Therefore, to facilitate adoption of power tillers within the possible limit of not affecting crop yields, the between row distance of crops should be widened, while the distance between plants may be reduced so that the number of plants or hills in an unit area will remain the same. It is only natural that some adjustments should be made in all aspects in crop cultivation when a new kind of power and new machine is to be adopted in an area.

(7) Attached Implements for the Power Tillers:

In the foregoing sections, we have limited our discussions to the power tiller itself, that is, the part corresponding to the cattle now on the farm. However, we should not neglect the farm tools attached to the power tiller that actually work on the soil and crops and performs the job. There are numerous kinds of farm tools, and each has its own specific technical features. It is impossible for us to discuss each and every one of them here. We shall discuss them briefly in the following according to experiment results.

1. Power tiller attachment found to be practical and well liked by farmers: —reversible plow, middle buster, power-take-off arrangement, etc.

2 Attachments considered to be feasible and can be improved:- include cage shape wheels (should be widened) cultivator (should be multiple rowed), breaking rotors (should have one more rotor at each side) etc.

3. Attachments found most unsatisfactory during trial use:—spike tooth harrow, smooth rim wheel, etc. These should be completely reformed. Merry Tiller lacks attachments that may perform works corresponding to some of the animal-drawn implements used in Taiwan, such as knife-tooth harrows, leveling poles, etc.

4. As there is a great variety of stationary work in the farms of Taiwan that are propelled by human power or small engines, it provides much room for

the use of power-take-off of the power tillers. Power tiller manufacturers should help the farmers install belt pulleys, etc. for using P.T.O. on these stationary working machines so that the annual working hours of the power tiller may be increased, and the farmer may have all the farm chores done with only one power unit, that is from his power tiller.

5. New machines utilizing tiller's engine power should be designed for work still being done by hand. This will increase work efficiency and reduce labor cost. Such a seeding machines, peanut threshers, etc.

6. When designing new farm tools, especially those for land preparation, intertillage, etc. the principle of "travel with working tools" should be fully exercised in order to get the highest efficiency from the power tiller.

7. When designing new farm tools, the working width and the depth should be well coordinated with the travel speed of the power tiller and meet the optimum duration of each job may be completed within the right season. An area of around 2.5 to 3 hectares should be considered as the area that the power tiller ought to take care of.

IX. Pre-requisites for Agricultural Mechanization in Taiwan

The agricultural mechanization movement, after it was initiated by JCRR and supported by organizations concerned, has been well received not only by agriculturists and farmers. The industrialists and financial circles have also expressed high interest in it and have started to consider what they can do to help promote this epochal movement. This of course has greatly encouraged us. However, to successfully implement the agricultural mechanization program, some pre-requisits have to be met. These are:

1. Local supply of reasonably priced ideal power tillers:

We have discussed ideal power tiller in the foregoing sections. After haveing studied all different types of garden tractors and power tillers from the available reference material, we are quite sure that a tractive and rotary type power tiller is nearest-to-ideal type of machine. But we should not advocate unlimited importation from foriegn countries as the country's over-all economy can not afford it. However, before a practical, dependable, and reasonably priced ideal power tillers can be produced by local manufacturers, we may have to import some to meet farmers' immediate needs and to cultivate their interest on power farming. The long range agricultural mechanization program should depend upon local supply of agricultural machines to meet the program's need.

Some manufacturers are now making Japanese style power tillers without considering whether they are adaptable to conditions in Taiwan or not, but just imitating or copying the Japanese model. These efforts will make no marked contributions to our agricultural mechanization program. It is our hope that farsighted industrialists will lead in designing and producing power tillers that will meet the needs of our farming conditions. By so doing, they will help much in laying the foundation for the future agricultural mechanization.

2. Careful study of proper method on utilization of power tillers and effective transmission of same to farmers:

Under this topic we mean the proper method on use of power tillers and their attachments for agricultural operations in Taiwan, the improved way on management of power farming farms, and the possible adjustment of cropping system after adoption of power farming machinery. These tasks are the responsibilities of the agricultural experiment stations. They should systematically disseminate the experiment-proven new methods to the farmers so that the later can use the power tillers in their own farms effectively to increase production.

3. Provision of competent service men and adequate repair facility at places convenient to farmers:

Repair service is usually considered the responsibility of manufacturers and their local agents. In the State of Nebraska of USA, there is a law known as "Nebraska Tractor Law". It states that a service station with full supply of replacement parts for each model of tractor shall be maintained within the confines of the State and within reasonable shipping distance of customer as a requisite for sale of tractors in the State of Nebraska. This is not difficult to comply with in U. S. A., as one service station can service tractors to a half-day's driving distance from the station or even farther. The situation in Taiwan, however, is different, because farmers do not have their own means of fast transportation and consequently the servicing area of a service station will be much smaller and hence the income from repair services will also be smaller. Under such circumstances manufactories have to raise either the selling price of the power tillers or the service charge, or both in order to maintain enough number of service stations which in turn will be a financial burden to the farmers. We suggest that power tiller repair service in Taiwan be located in the convenient marketing center of one or more nearby townships or Hsiangs. The power tiller users or local farmers associations may contract a reputable and popular machine shop or a motorcycle repair shop to

be the power tiller repair center of that area. The manufactories or dealers that have sold power tillers in that area should give the mechanics of this repair shop a well rounded good training on repair of their products, so that they can do the services satisfactorily. The manufactories should also make arrangement with the repair centers on stocking of spare parts for immediate use. Should the repair centers need some additional facility for satisfactory undertaking of this new line of work and lacks funds to do so, arrangement with Government or local farmers association may be made to help the repair centers, which eventually help the power tiller users. In this manner, we believe the repair work can be accomplished at the lowest cost.

4. Satisfactory supply of fuel to power tiller users.

Because use of petroleum fuels in Taiwan is controlled by government on allocation basis, users of power tillers had to obtain the fuel from the black markets in the past. To help promote the agricultural mechanization program, JCRR, PDAF, PFA and the China Petroleum Corporation have drawn up a set of measures for allocation of fuel to small power tiller users. These measures have been revised and endorsed by the Board on Allocation of Liquid Fuel of Taiwan Provincial Government. This regulation though has not been promulgated by the Provincial Government yet but it is now only a question of time. The content of these measures may be summarized as follows: i. Farmers are entitled to buy ample amount of fuel at government announced official prices, ii. Local farmers' association, may handle the purchase of fuel collectively for their members to save each individual farmer's time, as otherwise they have to go separately to the gasoline stations which are located away from most of the farms. When these measures become effective, local farmers associations may need some simple but essential equipment to store and redistribute fuels. Of course the farmers association may also delegate this function to the nearby power tiller repair center, so that farmers can refill fuel and repair their power tillers at the same place.

5. Long term credit at reasonable interest rate or instalment plan to help farmers buy the power tillers.

A power tiller and its essential and immediate attachments will cost a total of over NT$10,000. This is quite a big sum for the average farmers. Although one power tiller will have a service life of six or more years, it is quite difficult for farmers to make such an advancement in one lump sum. Two possible ways to solve this difficulty are: i. the manufactory concerned to offer installment payment plans, ii. farmers to borrow from agricultural finan-

cial organizations and repay the principal and interest by installments. Both measures will enable the farmers to pay a small down payment and get the power tillers for immediate use. In this respect two things that cause the farmers' the greatest concern are the interest rate and the length of the loan term. At present the Taiwan Land Bank, Provincial Cooperative Bank and Provincial Food Bureau have all started to extend power tiller purchasing loans. The monthly interest charged by the Land Bank and the Cooperative Bank is 12%, or 14.4% per annum, to be repaid in six installment in three years. The Food Bureau lends at a daily interest of 4.0%, or 14.4% per annum with a period of one and half years, repayment to be in terms of rice. The PFA in selling Merry Tillers to farmers also allows installment payment at a monthly interest of 17%, or 20.5% per annum with compound interest, for a period of one and half years. The interest rates under the three systems are all quite high. However, we believe these agencies must have reasons for doing so. It is our hope that rural economists will study the profit made by farmers from their farming enterprice and stipulate a reasonable interest rate accordingly for the power tiller purchasing loans, with consideration of the availability of funds. The period of loan should be extended as long as possible according to the serviceable life of the power tiller. This will make the credit plan really practical and helpful to the farmers.

The above comprises the pre-requisites of the agricultural mechanization program. They are all indispensable and supplementary to each other as the law of minimum in the fertilizer science, shortage of either one of them will affect the sound development of the whole program. Therefore no single element should be ignored or overemphasized.

X. Summary

(1) In the spring of 1955, the JCRR, in an effort to ascertain the possibility of the use of small power tillers in Taiwan farms, purchased from Japan a driven and rotary type power tiller (represented by the Kubota power tiller) and a tractive and rotary type power tiller (represented by the Merry Tiller) for preliminary observation and trial use. Although both types have merits and disadvantages, but, as a whole, the tractive and rotary type power tiller is found to be more suitable for use in rural Taiwan.

(2) To further study the adaptability of small tractive and rotary type power tiller in Taiwan, JCRR and PDAF purchased 13 power tillers of this type and tested them in 13 agricultural experiment stations scattered all over

the Island. The findings and results of the tests conducted in the past year are:

1. For plowing, the power tillers are good enough, except on very heavy soil and deep muddy fields. The depth of plowing averages one inch more than that achieved by cattle; the time consumed is about half the time needed by cattle.

2. For secondary land preparation such as pulverizing, harrowing, leveling, etc., the efficiency of the power tiller is about the same as that of the cattle. Soil prepared with power tillers is in better granular form but not as level as that prepared by cattle. When using cage shape wheels on power tillers in preparing paddy fields, grasses may be pressed into the soil deeper and will greatly reduce their chances of re-sprout.

3. For plowing and intertilling in tea plantations, citrus orchards and corn fields the power tiller are far better than human and cattle.

4. Attention have been directed to the use of power tillers' power-take-off for stationary works on the farm. Trials have been made on pedal rice threshers, fiber decorticators, sweet potato slicers, etc, with gratifying results.

(3) Annual working hours of the power tiller is an important factor in determining the economy of use of power tillers. We estimate that an area of 2.5 hectares will be able to keep the power tiller busy for 1,000 hours a year. If more of farm work can be accomplished by the power tillers in the future the area of economic utilization of power tillers may be further reduced.

(4) Power tillers should be owned individually. If the land owned by such individual is limited in size and can not give the power tiller a 1,000 hour work load in a year, the owner may work for others at cost or cost plus basis. This will ensure full utilization of his capital investment and proper care of the power tiller. If the affordability of an individual is not enough and he can not borrow enough money at reasonable interest, he may purchase the power tiller jointly with one or two of his neighbors and use the power tiller by turns.

(5) We think the tractive and rotary type power tiller is more suitable for use in Taiwan. To meet the fuel supply status in Taiwan, gasoline engine should be used. A 2.5 HP model and a 3.5 HP model will meet the need of most of our farms. However, one or two models of even larger power (5HP or more) for farmers that farm on heavy soil will also be fine. Power tillers should be equipped with three kinds of wheels for work in paddy fields, upland fields an travel on roads. The farm tools attached to the power tillers should be improved with the conventional farming tools as reference to ensure complete

adaptation. Design of these implements may be undertaken by agricultural engineers of agricultural schools, colleges and experiment stations.

(6) Some pre-requisites for promotion of agricultural mechanization are, i. Local supply of reasonably priced ideal type of power tillers, ii. Careful study of proper method on utilization of power tillers and effective transmission of same to farmers, iii. Provision of competent serviceman and adequate repair facility at places conveneint to farmers, iv. Satisfactory supply of fuel to power tiller users, v. Long term credit or installment purchase plan to help farmers with limited purchasing power.

At the end of September 1957, we made a rough survey, which revealed that there were some 180 farmers then using power tillers on their own farms instead of buffalo. Of the 180 power tillers, 95% belonged to the "tractive and rotary type" and about 5% the "driven and rotary type". Of the "tractive and rotary type" tillers there were Merry Tillers (156 units), Mametora tillers (14 units), and local made Hsing Nung tillers (12 units). Of the "driven and rotary type" tillers, there were Kubota tillers (4 units), Akitu tillers (2 units), and Iseki tiller (one unit). This indicates firstly that Taiwan farmers will accept the power tiller as a good substitute of their time-honored working mate, the buffalo; and secondly that the "tractive and rotary type" power tiller is more favored than the "driven and rotary type".

When preliminary tests indicated that power tillers can be profitably used in Taiwan, our farmers have shown their acceptance of it. There are, now, six local machinery manufacturers manufacturing power tillers. At this juncture, it is sincerely hoped that every one concerned will help in promoting the agricultural mechanization program to eventual success.

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