*International specialized media for agricultural mechanization in Asian developing countries.*

# AMA

## AGRICULTURAL MECHANIZATION IN ASIA

VOL.IX,NO.3,SUMMER 1978

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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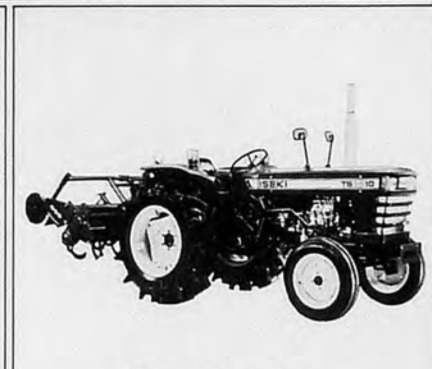
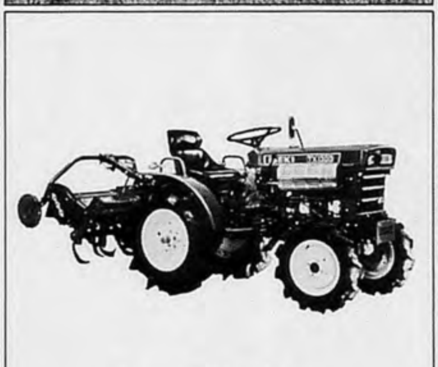
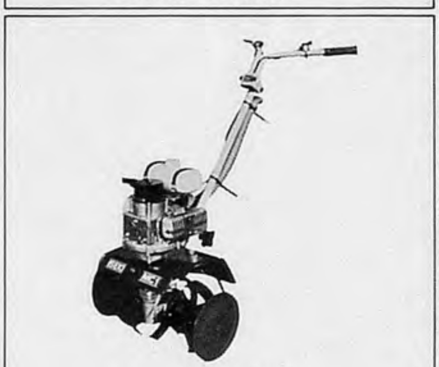


Tractor TS series



Tractor TX series

Power Tiller KS series



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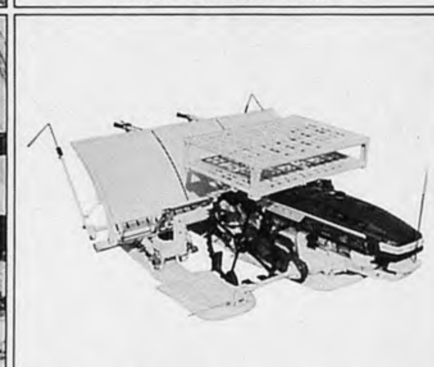

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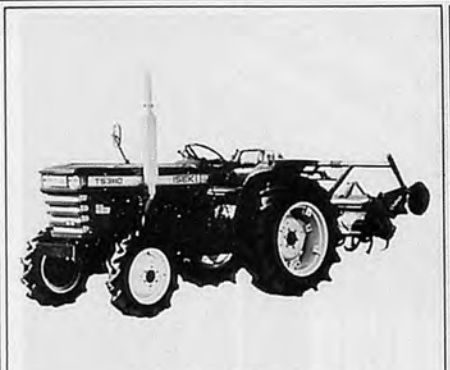
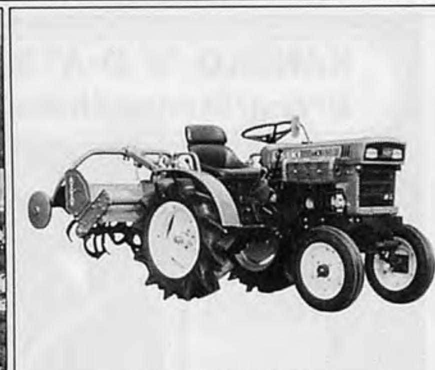


Tractor TS series



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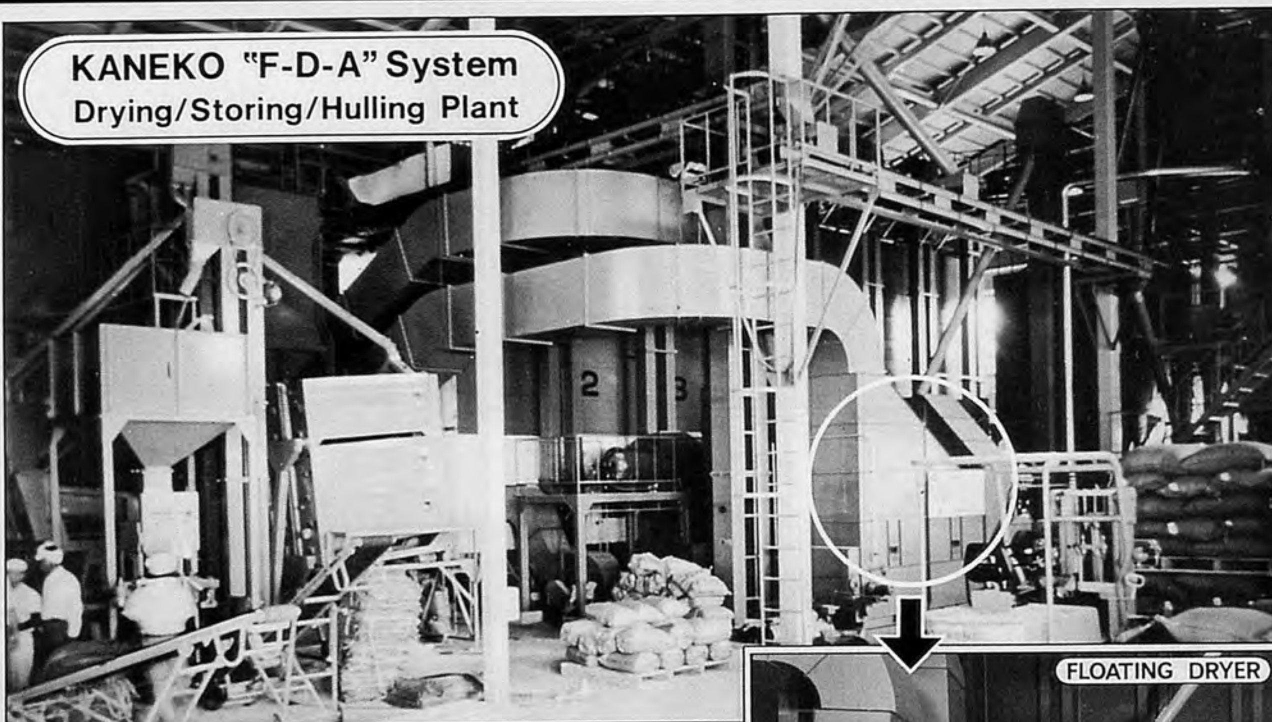


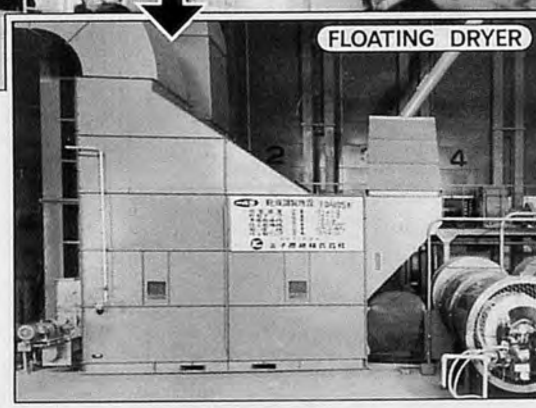


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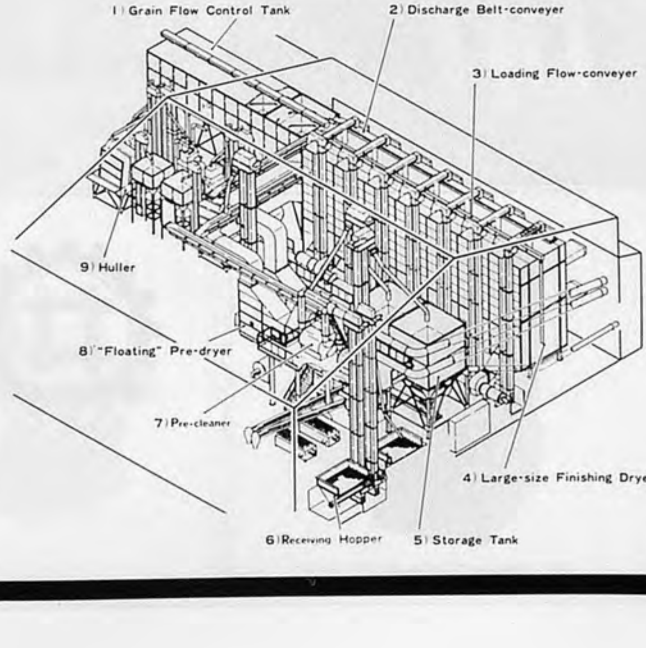

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## AGRICULTURAL MECHANIZATION IN ASIA

VOL.IX,NO.3,SUMMER 1978

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## Preface

The Special International Conference on "AGRICULTURAL TECHNOLOGY FOR DEVELOPING NATIONS : Farm Mechanization Alternatives for 1-10 Hectare Farms" was held in the University of Illinois in U.S.A. from May 23 to 24. There attended over 300 specialists in various fields including farm machinery industry, and, despite of such a short term as only two days, many problems of very wide range were discussed during the meeting.

One of the most remarkable point of this conference is that such a great conference on the problem of small-sized farm machinery was held in the U.S.A. where they had developed the large-sized farm mechaization by now, and another is that Deere & Company took part as one of the co-sponsors of this conference.

Almost all farms of the world are small farms. In this sense, the problem of farm mechanization for the small farms is the greatest one in the world.

However, because of the lack of purchasing power, such mechanization has made very slow progress, and so the big manufacturers of farm machinery in advanced countries have hardly took interest in this problem by now.

But at this conference we found that these manufacturers of large-sized farm machinery in advanced countries began to show their constructive manner to wrestle with this problem in earnest. This is a very good news, because it will be a great power to develop the farm mechanization in developing countries of the world for the future.

And besides, they debated also on energy which is the very current problem. I am sure that all the people concerned must recognize again that there are still more difficulties in farm mechanization in developing countries concerning the energy problem, such as the possibility of use of the fossil energy in the future in developing countries, the problem of the alternative energy in case of the drain of the fossil energy, etc.

In order to develop the farm mechanization in developing countries in considering together these problems, I will like to keep much more active communication among the specialists of the world through "AMA" for the future.

I sincerely hope the cooperation of all the readers of "AMA"

Chief Editor
Yoshisuke Kishida

July, 1978
Tokyo

# CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. IX, No. 3, Summer, 1978

# Intermediate Agricultural Mechanization in East Asian Countries

by
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The following observations and impressions are presented as a part of the survey of agricultural mechanization for semi-arid tropical crops undertaken for ICRISAT (International Crop Research Institute for Semi-Arid Tropics) in the countries of Japan, South Korea, Taiwan, Indonesia and the Philippines in October and November, 1977. The five-country study is a part of the worldwide survey undertaken by Mr. Gerald Thierstein of ICRISAT. The objective is to bring together information on locally manufactured and utilized machinery as well as those being developed in various countries of the world. The focus was on agricultural machinery applicable to rain-fed agriculture and appropriate for small farms in the range of 10 hectares and less. Major emphasis was placed on animal and small mechanical power equipment for tillage, planting, seeding, fertilizer application and harvesting.

The five East Asian countries included in this portion of the overall survey have wetland paddy rice as the major crop. Because of this some of the machinery development was not directly applicable to dry land crops. Much of the equipment for tillage, plant protection, harvesting and post harvesting processes was, however, also applicable to upland crops as well as wetland paddy. A few specific rice crop machines such as the mechanical rice transplanter was not included in this survey. Small two-wheeled power tillers and walking tractors can, however, be equipped with paddy wheels for wetland mobility or with regular wheels with tires for dry land cultivation.

The five countries surveyed were in various stages of mechanization development for agricultural production. In Japan, for instance, agricultural mechanization is now designed mainly for labor efficiency. Some such equipment was then inappropriate for the focus of this survey towards small farms in the semi-arid tropics of the world. Selective impressions for each country are summarized briefly in this report. The five countries are reported in the order they were surveyed.

## Japan

Agricultural mechanization in Japan has progressed to a high level of sophistication. The mechanical horsepower available per hectare of cropland is the highest in the world at about four (Giles, 1975). This high level of mechanization is, however, utilized on small farms that average slightly above one hectare. Even though the various machines are quite labor efficient in themselves, the labor input per hectare of cultivatable land in Japan is comparatively high : about 800 hr per ha for rice. At the same time, the mechanized agriculture payoff has been exceptionally high : average rice yields at five tons per hectare (Sakai, 1977). High yields have not been necessarily brought about by mechanization, but rather by the combination of mechanization along with other inputs of water control, high yielding varieties, plant protection, fertilizer application and good cultural practices. The high governmental subsidization of a guarateed rice price to the farmers at a level two to three times the world market price has been successful in stimulating increasingly higher total production levels of rice each year (it was about one U. S. dollar per kg of brown rice in 1976). The success of subsidization not only made the farmers fairly prosperous, but stimulated rice production beyond the point of self-sufficiency for the country since some years ago. Japan was then confronted with decelerating the production of rice and diversfication to other crops. They are still working on this program.

Japan mechanized agriculture through the 1950's and 60's with the two-wheeled power tiller and walking type tractor. Power tillers in the 10-horsepower range were first introduced. The introduction of smaller power tillers in the four, five and six horsepower ranges came later as they were more applicable to the individual farmers. The smaller power tillers made it possible for the majority of farmers to own their own mechanical power unit for primary tillage (about five million farmers owned 3.4 million power tillers in 1974). The policy of providing mechanization appropriate, feasible and economically suitable for small farmers was also responsible for the introduction of tens of thousands of stationary threshers and small, simple, box-type grain dryers (3.3 million power threshers in 1967 and 1.74 million grain dryers in 1975).

Today a vast majority of all the rice produced in Japan is transplanted with mechanical rice transplanters and harvested with small, self-propelled combines and dried mechanically under controlled conditions. (In 1976 there were one million transplanters and nearly two million combines on farms.) The introduction of the two-wheeled tractors peaked first in 1962 at about 500,000 units per year and again in 1968 at the same level (Sakai, 1977). Now four-wheel tractors are being manufactured and introduced at about 300,000 units per year. The four-wheeled tractors run in the range of 15 to 35 horsepower and 80 percent is delivered with the rotary tiller. Consequently, much of the manufacturing in Japan and all of the research and development in agricultural machinery is focused towards four-wheeled mechanical powered equipment. For example, the agricultural machinery research station at Ohmiya, near Tokyo, is concerend mainly with the development of bean and rape seed harvesters, along with fruit harvesting and handling equipment. These specialty machines are all adaptable to four-wheeled power units and designed for labor efficiency with little concern for the initial high capital cost.

The Agricultural Machinery Research Station library at Ohmiya was undertaking the annual accumulation of all manufacturers technical and sales bulletins for agricultural equipment produced in all countries. The program has been underway since two of years ago and thousands of folders and brochures have been accumulated from companies around the world. The library now has on file of essentially all the Japanese manufactured equipment specifications and is contacting other manufacturing companies in other countries. The aim is to obtain catalogs and leaflets that provide technical specfications for equipment along with prices. The procedure is for information to be obtained first from larger companies around the world that generally produce equally large equipment. Obtaining side information from small companies that produce appropriate mechanization for small farms will be more difficult and time consuming. Therefore, it is important for the ICRISAT to develop a linkage with the director of the Research Station library in order to complement the survey of intermediate technology for semiarid topical cropland.

A number of individual agricultural machinery companies in Japan were visited. The Mametora Company was, for example, manufacturing and exporting the power transmission assembly for small power tillers in the 6-and 7-hp range. They have set up technical assistance programs with a few companies in other Asian countries which are capable of manufacturing most of the framework for a power tiller, but not the gears necessary for the transmission assembly. This approach can benefit some other Asian countries for a few years. The Otake Company is still emphasizing the manufacture of small threshers, forage cutters, weeders and cultivators. The smallest cultivator is a modification of one originally designed at the International Rice Research Institute (IRRI). It is powered by a very small 3-hp engine and is adaptable to upland cultivation. The Takakita Company is innovative in developing different kinds of equipment, particularly pertaining to livestock production such as equipment for forage cutting and handling, and animal waste disposal. Originally the company was a plow manufacturer and still continues to manufacture plow and cultivator equipment for two-wheel as well as, now, four-wheel power units.

Fig.1 At the Takakita, Agricultural Machinery Company in Japan. President Takakita right, Professor Merle Esmay, in center, and Dr. Makoto Hoki left.

The Sukigara Company also manufactures very small mechanically powered cultivation equipment. The small machines range from a 1 to 1.5hp mono-

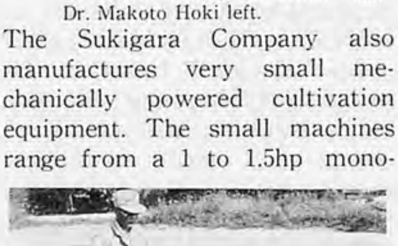

Fig.2 This is a small 1-1/2 hp monowheel cultivator produced by the Sukigara Company of Japan. It is low cost and should have application in small upland fields.

wheel cultivator to 5-8 hp two-wheeled units. The Sukigara Company still shows a hand, push-type cultivator in their brochures Evern as they have not manufactured many in the last few years, they would manufacture large number when orders are receiued.

All of the agricultural machinery companies visited emphasized interest in export markets and were willing to make various arrangements of joint technical programs with companies in other countries. The export prices for agricultural equipment are considerably below domestic prices. Domestic list prices were readily available, but export prices were difficult to obtain as they vary with time, place and conditions.

## South Korea

Power untis for agricultural mechanization in South Korea have been focused mainly towards the 10-12-hp tillers in the past 10 years. The quasi-government Dae Dong Manufacturing Company is by far the largest agricultural machinery company and manufactures some 80 percent of the locally-maqe power tillers in the country. The company started over 10 years ago with a joint venture technical assistance program with Mitsubishi of Japan. However, Dae Dong is now operating independent of Mitsubishi, the parent company. I talked to various officials of the Dae Dong Company and other Koreans in government and university in 1971 and 1972, while working with the Exotech team study of agricultural mechanization, about manufacturing smaller power tiller that would be less expensive, more maneuverable in small fields and that small farmers could more readily afford. In 1977, there was no evidence of the manufacture of smaller power tillers. The Dae Dong Company did show a lower horsepower unit on one sales leaflet, but when questioned about it said were not producing any. The Agricultural Machinery Research Station at Seuwon did indicate however that they were giving some attention to the development of a smaller power tiller, and had a prototype of the IRRI designed unit in their shop for evaluation and modification for Korean conditions. There was some evidence at the developmental planning level that possibly there was a place for the smaller power tillers for the small farmers. There seems to be a compulsion for modifying the IRRI unit even though it was engineered, designed and tested in the Philippines for wet paddy and dry land conditions. It is somewhat questionable whether modifications add or detract from the capability and quality of the original unit. While some countries have special conditions and requirements for machinery and qualified engineers for redesigning, the original desizn need not necessarily be modified for each country.

The Korean Agricultural Machinery Research Station was also working on an attachment-type reaper for rice : another type of machine that I advocated in 1971 and 1972. I did not, however, find evidence of any Japanese company that had manufactured one in the past before going to binders and combines. An attachment-type reaper for a power tiller would be considerably less expensive than the self-propelled units now being manufactured by the Japanese companies as it would only reap and lay the stalk paddy down in uniform, unbound bunches. This step would adapt well to threshing in the field with a portable drum-type unit. The reaper would adapt well to the Taiwan system where the small bunches, cut by hand sickle, are picked up by hand and carried a few steps to the portable drum-type thresher. The Korean Research Station had a prototype model of the experimental unit that still needed some further development, but had possibilities. However, officials said they were giving up on its development because it was too late. It did not fit into the patterm of combine harvesting which is being promoted and considered by the planners. Some combines for custom operators may be in order, but it seems that there still is an interim period of a number of years before combines can totally take over or shuld totally take over with their high capital investment requirements. In general, there seemed to be little concern for the small one-hectare farms which is typical for Korea. The larger machinery companies, such as Dea Dong, were not interested in producing small equipment ; and ironically even the small, somewhat primitive shops (of which I visited a couple) were also not satisfied to produce small equipment for the average sized farmer. One small shop in the edge of Seoul was making some small hay crushers for small livestock farmers, but was obsessed with development of sophisticated dryers and hay pelleters. The shopowner had plans for the IRRI dryer and had made a few, but was instead producing a few much more sophisticated upright circulating grain--type dryers with sophisticated controls. The pelleter was even a more expensive and, of course, power requiring type of machine which he was attempting to develop from scratch.

One of the most interesting small shops visited was producing simple, low-cost, drum-type threshers. The threshing units were made of plywood over a wood frame for housing the engine powered cylinder. The opeator produced two different sizes of threshers. One, he said,

**Fig.3** A small low-cost drum-type thresher still being developed by a Korean small shop for sale to individual farmers.

**Fig.4** A custom operator threshing crew at work in South Korea. The larger machines can only be purchased and operated by custom operators.

was for the individual farmer and the other, a bit larger, was for custom operators. He was indeed providing a service for the small farmers and small custom operators in producing threshing machines that had good capacity, but were still not overly expensive. The units were light enough to be portable so they could be moved around in the field. The units were not, however, moved continually behind the harvesting operation as the Taiwanese do. This shop manager was also building some rice-straw-twine making machines that were foot pedal operated, and some rice-straw-twine bag making machines. The bag making machines were powered by a small engine. These machines were being used by some farmers of custon work during off seasons as an addi-

**Fig. 5** These are looms for making rice straw bags. A small Korean shop makes them and and sells to farmers for off-season enterprises.

tional source of income.

The Koream agricultural machinery manufacturing companies belong to an agricultural machinery association which controlled and coordinated production and markting of the various agricultural machines through the farmers' assciations.

All of the agricutural machinery manufacturing companies except the smallest shops were very actively interested in exporting machinery. Each of the larger companies visited had beautiful multi-color leaflets in English that had been put together for publicity and promotion. Exportation is a national policy that is being extended to the agricultural machinery industry even though it is quite new in Korea. A few companies were already exporting some products and others were negotiating with companies in other countries to set up joint ventures. I had previously heard of some concern by various Japanese manufacturing companies about the Korean companies moving into the export business with essentially Japanese designed equipment and, of course, providing considerable competition. Many of the Korean companies have intially obtained basic designs and technical know'how from Japanese companies and can now possibly produce low-cost machines because of lower labor costs and sell them on the international market at a lower price than the Japanese.

## Taiwan

In 1962, when I first became acquainted with Taiwan, their economy might be described as depending upon the four B's, Bicycles, Buffalo, Bamboo and Babies — Bicycles for transportation, Buffalo for tillage and hauling, Bamboo for most everything, and Babies for population growth. By 1977, Taiwan had changed greatly and seemed to be dependent upon the four M's, Motor bikes, Mechanization, Migration and Matriculation — Motor bikes for transportation, Mechanization for agriculture, Migration of rural youth to the cities, and Matriculation for education.

This possibly over simplifies the changes in Taiwan, but does reflect to some extent the transition that has taken place in the past 15 years. From a transportation standpoint, there are many other vehicles now, including cargo trucks, pickups, and panel wagons ; but motor bikes seem to dominate the roads, particularly in the rural areas. Mechanically powered machines are rapidly replacing the water buffalo in agricultural production, aithough there are still many draft animals (417,000 draft animals in 1960 and 188,000 in 1976 ; 3,700 power tillers in 1960 and 56,000 in 1976) (Pang, 1978). Migration to the cities, particularly by the rural youth, is a predominant trend. The industrial development in Taiwan has provided job opportunities and the migration has brought about labor shortages in agriculture, which is now forcing labor efficient mechanization. Bamboo is still used as a versatile material and you still see bamboo scaffolding many stories high on all sides of some new construction of multi-story structures, but its use has tapered off somewhat in the last 15 years. As for babies and the population, there has been some concern about population growth, and its drowth has been curtailed somewhat. Insofar as education is concerned, the Chinese have always been interested, but now with a better financial means, for most families in both urban and rural areas, Education is taking on a new dimension at both the middle school and the higher educational level.

The shortage of rural labor is beginning to take some toll insofar as agricultural production is concerned. The multi-cropping index for Taiwan, for example, has dropped from a high of 185 in 1965 to 175 in 1976, which may, in part, be a reflection of the lack of labor to follow up with sequential crops. Intercropping is also diminishing because of labor shortade and the necessity to mechanize. Taiwan agriculture has had one of the lowest total power inputs per ha (about 1/4 hp per ha in 1965 and still less than 1/2 hp) with one of the higher production levels per hectare (about 3.5 tons per ha). On the power versus production graph developed by G. W. Giles (1975) for various countries of the world, Taiwan is an exception because it had attained the highest production with the lowest power input. The power includes hand, animal and mechanical power, and the level of production of 3.5 tons per ha was aggregate for all crops. The power/production index for most

Fig.6 The combine assembly line of a new Taiwan company just beginning production of these Japanese-type combines. The expensive combines run by custom operators is a change being resorted to in Taiwan to overcome the labor shortage in the rural areas. They represent a drastic change from the individual farmer-owned drum threshers which have been operated by farm families for the last decade or two.

other countries fell quite neatly onto either one of two straight lines. Taiwan successfully developed a very intensive, mostly irrigated agriculture.

Shortages of labor that have developed in the past five years have caused the development of mechanization for the purpose of labor efficiency. I was surprised to see a number of Japanese-type combines in the harvest fields as I rode a train through one of the harvest areas in Southern Taiwan. The jump to comblines from the portable drum-type thresher, which most farmers owned and operated themselves, was a great change. (In 1965 there were 205,784 threshers in Taiwn — mostly the foot pedal drum type. By 1976 threshers had dropped to 128,232 and combines increased to 2,811.) (Peng, 1978). Not only was it a change from the standpoint of mechanization, but also in that the combine is generally custom operated while harvesting before had been a family operation.

The mechanzation of harvesting with expensive machines that are custom-owned and operated is one way to approach mechanization and has some merit, particularly for the harvesting operation. I was surprised, bowever, to find that the Taiwan manufacturers of power tillers were only making the large ones that run from 10 to 19 horsepower in size. These large power tillers can be purchased and operated only by custom operators. In 1976 there were 55,748 power tillers for 870,000 farms that average about

Fig.7 This is a small forage cutter produced by the Chung-Yuan Company in Taiwan. Mr. C. D. Cheng, in dark shirt, is the manager.

one ha each. This is one for each 15.6 farms as compared to Japans peak of one for each one and one-half farms. (Peng, 1978) It would appear then that the government policy is not only to make small farmers dependent upon custom operators for combining their crop after it is grown, but also for primary tillage in preparing the land. Mechanical rice transplanters are also coming into use, but they are not as large and expensive as combines (6,108 transplanters in 1976).

Some of the smaller manufacturers in Taiwan, as those in Korea, seemed not to be content with developing and manufacturing small machines of the type that might be purchased and operated by individual farmers. For example, two manufacturers that were making rice dryers were visited ; however, not the small, simple, flat-bed dryer, but rather the more expensive, complex, upright, circulating-grain type. The Tatelin Company, somewhat like the Dae Dong Company in Korea, was manufacturing power tillers of a Japanese company design. This Taiwan company, located in Kaohsiung, has a tremendous manufacturing capacity that officials said would be adequate to produce at least 7,000 power tillers a year, which is the total number now being marketed annually in Taiwan. I believe that with a little effort. output could probably be pushed to 10,000 units. Tatelin, however, was only producing 2,000 untits per year, as there are other companies in the business of helping supply the 7,000 units to the Taiwan agricultural sector. The management of the Tatelin Company, as well as some of the others visited, complained of the very limited market for their equipment. The 7,000 power tillers marketed annually was an example. Taiwan is a small country, but the Tatelin Company as well as others, and including some policy-makers, were totally ignoring the market for 870,000 individual Taiwan farmers. The individual farmers provide a tremendous market for smaller, less expensive equipment. Japan, as opposed to what both Korea and Taiwan are now doing, did manufacture and market equipment for the individual use of farmers of that country (see the Japan portion of this report). Although the early manufacturers of power tillers and walking tractors in Japan started out with the 10-and 12-hp units, they soon changed to the smaller ones of the 5-hp range which the small farmers could and did buy throughout the country.

The Taiwan agricultural machinery manufacturing companies, as those in Korea, are all looking outward for export markets and, in a number of cases, are exporting a good deal of equipment. One exception to the trend of large equipment has been the manufacture and marketing of small, hand-type sprayers for plant protection. These have been manufactured by Taiwan companies by the tens of thousands and sold domestically, and now a number of companies are manufacturing them for export. Two or three Taiwan companies visited were exporting then pioduets to Indonesia.

### Indonesia

Indonesia is a country of many paradoxes. One can oversimplify and make many quick conflicting judgements such as : there is a high rate of under-employment and unemployment so agricultural mechanization should not be introduced. The country is not self-sufficient in food grain production, thus there is a need of more inputs—possibly mechanical power for primary tillage. Rural people, particularly the young,are flocking to the cities, Jakarta mainly ; so there is a need for improved rural condition to slow down this movement. Transmigration programs back to the rural areas, particularly onto other islands, may never be able to keep up with the rural-to-city movement. A country that is introducing one-half million motor bikes per year should be thinking about improved mechanization for their basic industry—food production.

Indonesia, needless to say, is just in the beginning phases of agricultural mechanization. In that respect it is an ideal time to plan for the type of mechanization appropriate for the country in the coming decade. In-country research and development as well as local manufacturing should play a critical role in the process. All possible information on appropriate mechanization should be obtained from around the world, and local manufacture developed so as not to be dependent on the importation of machines from any other country on a long term basis.

During three days of travel by automobile, in the rice production areas of west and Central Java I observed just one power tiller being used ; even thouge it was the beginning of the monsoon period and primary tillage was underway in many fields. Appropriate mechanization can be selected so as not to replace and increase unemployment, but rather increase overall production and improve the living conditions and optimism of the rural people. In this way mechanization can help satisfy rural people where they are at, rather than forcing them to the cities because of the hopeless rural conditions.

Indonesian manufacturers of small agricultural equipment, which are for the most part pmall companies and shops, are having difficulty getting started and maintaining a viable business. This is true, for example, of manufacturers of back-pack

Fig.8 This is a small labor-intensive shop in Indonesia. Back-pack, hand-operated sprayers were being fabricated for local use. Quality control is a problem for these small shops. They need help for the production of durable products to meet the competition of imports.

sprayers even though thousands are being regularly imported from Taiwan. The small manufacturers have both engineering and marketing problems and will not survive, as they have not in Taiwan, unless help is provided. Production of quality products is difficult for the small shops to achieve. This has been particularly true in the past few years while they were getting started. Some of the locally made products may now be as good as the imports, but unfortunately the farmers are not convinced, hence prefer imports even though more expensive.

All the agricultural equipment manufacturers visited, hoth large and small, were having marketing problems. They did not seem to have dependable orders even though there may have been a broad general demand for the equipment. Some of the agricultural equipment manufacturers have had to revert to sidelines in order to survive. One in Surabuya, for example, had reverted to truck and trailer steel box fabrication. Another in Yogyakarta was relying on the production of nuts and bolts for continued production income. Introduction, manufacturing and marketing of agricultural equipment is under considerable government control, thus the small shops are dependent upon programmed orders. Some agricultural equipment are manufactured by quasi-government companies. One, in particular, is operated by the military. This company occasionally sub-contracts equipment orders they cannot handle to privately operated shops.

A cooperative organization of manufacturing shops was visited in Central Jave.a. There is some specialization among them. For example, one specializes in foundry work. The cooperative shops are only beinning to go into the production of farm machinery in a small way at this time. One shop was visited which was filling an order for water pumps. This cooperative approach appeared to be effective and practical.

Kubota of Japan has in 1977 put up a local fact9ry near Semarang in cooperation with an Indonesian firm for the manufacture of small diesel engines. They plan to go into power tiller production within another year or two. A similar enterprise by Mitsubishi is planned near Surabaya. Under government regulations 30 percent of the components must be locally produced.

Some IRRI designed equipment (the power tiller in particular) was observed at three fo four small shops ; however, only a few units had been manufactured. There was little market available to these small manufacturers for such machines. The small manufacturers seemed overly concerned, however, about redesigning the IRRI machines. Granted the machines may not be perfectly designed by IRRI for every location, but it is questionable whether the small shop owners without engineers have the expertise to improve them appreciably.

### Philippines

The Philippines have (within a one day driving radius of Manila) a full range of manufacturing capabilities and facilities, from modern sophisticated plants to small shops with only welders and no power operated equipment. Manufacturing in the Philippines cannot be appreciated without understanding the phenomenon of the "jeepney". Following Wold War II a number of small entrepreneurs procured army surplus jeeps and remodeled them as small bus-type personnel carriers. The bodies were refabricated to provide a rear entrance with a bench on either side. The capacity of each is from 10 to 20 people. They became available at a time when transportation vehicles were scarce and have flourished ever since, particularly in the Manila area. The jeepney's run regular routes as buses and it costs little to ride them. A part of the phenomenon, and possibly a factor related to their acceptance, has been their extensive decorations and ornamentations. Each is brightly painted with individualized designs.

The small roadside jeepney fabricators provide training ,or many skilled people in metal work and engine reconditioning, as repair and maintenance. The army surplus jeeps are long gone, but the innovative fabricators have continued by importing various needed components, mainly engines and power chains. At least one jeepney fabricator is importing used Japanese diesel engines. Most of the jeepneys now being made have diesel engines for fuel economy. The largest jeepney manufacture has gone completely modern and now has a new mechanized and automated assembly plant in which they are fabricating four or five types of vehicles along with the jeesneys. This large company is installing all new Japanese components in all of the vehicles.

A number of the jeepney manufacturers have ventured into the manufacture and fabrication of various types of agricultural equipment. The manufacturing skills they acquired from the jeepneys help considerbly in manufacturing other equipment. The availability of local manufacturers combined with the machine designs available from nearby IRRI have played a significant role in the accelerated introduction of agricutural mechanization. In the Central Luzon area, IRRI designed equipment, particularly power tillers and threshing machines, dominate the agricultural equipment now in use. From the roadside it appeared that at least half of the power tillers in the rice paddy fields were of the IRRI design. It was observed in visiting a number of small agricultural equipment manufacturers that they were fabricating essentially an IRRI design, but had their own patents on them. IRRI patents their newly designed machines, but evidently it is quite easy to obtain another patent on a similar machine by making a few changes. There is natural pride in manufacturing their own identifiable machine ; however, one manufacturer answered my question about such such patenting by stating that he could with a patent include research and development in his sale price. This, to me, indicates a controlled market through government programs in which free market competitive pricing is not a factor. The manufacturers then must, as was the case in Indonesia, depend on

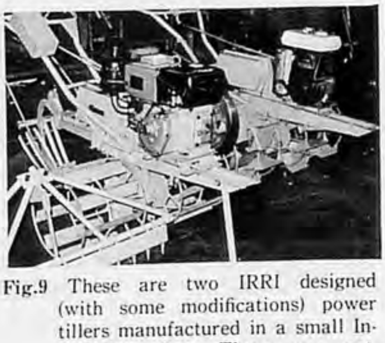

Fig.9 These are two IRRI designed (with some modifications) power tillers manufactured in a small Indonesian shop. There was not, however, a market for them as government programs do not promote them. The small shop has had to resort to truck body fabrication to to stay in business.

sporadic government programmed orders to stay in business.

Only the smallest shop visited was fabricating a simple a foot-pedal drum thresher which many individual farmers could afford. The more prevalent IRRI designed threshers being fabricated included the mini-portable one and a trailer mounted axial flow, through-put type. Only custom operators could afford these power threshers. Custom threshing is becoming more popular in some areas. This is in spite of a fairly universal custom of small groups contracting with rice growers to weed, harvest, thresh and clean the paddy rice for a percentage of the crop (six percent in some areas). One custom operator stated that he had labor groups hire him to thresh with his mechanical equipment. According to this custom operator the rice grower also favors mechanical thresher because of reduced losses. The labor groups traditionally thresh by hand beating, which can prolong threshing, cleaning and drying.

A few hundred flat-bed rice dryers have been introduced around the Philippines through government agricultural programs. These have been mainly the plywood box unit designed by the Institute of Agricultural Engineering and Technology of the University of the Philippines, Los Banos. IRRI has nearly completed the design and development of a new upright fixed-bed dryer. It can be fabricated of low-cost local materials, and in particular does not require the expensive perforated metal floor needed for the horizontal box units. A few small companies are fabricating dryers of their own design, but at least in one case it appeared to be very expensive for just being a fixed bed horizontal type unit. Some of these expensive units were purchased by rice processing plants. The expensive unit did have a rice hull burner sttachment for heating the drying air which made it somewhat more attractive. It was observed at one mill that sun-drying was still practiced even though they had one of these rice hull dryers. The dryer was evidently just for emergencies during wet, cloudy weather when sun-drying is not possible.

## REFERENCES


1. Peng, Tien-Song, 1978. "Problems and Solutions : Development of Farm Mechanization in Taiwan"", Taiwan Agricultural Machinery Guide, J. C. R. 37, Nanhai Road, Taipei, Taiwan, R. O. C.
2. Sakai, Jun, 1977. "Development Current of Agricuitural Machinery for Japanese Rice Cultivation and Farming Structure", Agricutural Mechanization in Asia, Tokyo, Japan, Volume VIII, No.4, Autumn, pp.66-78.
3. Giles, G. W., 1975. "The Reorientation of Agricultural Mechanization, Part I, Policies and Attitudes for Aciton Programs", Agricultural Mechanization in Asia, Tokyo, Japan, Volume VI, No.2, Artumn, 1975, pp.1-16.


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# Farm Size, Labor Employment and Farm Mechanization in Bangladesh

by
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## Introduction

Bangladesh is a predominantly agricultural country. Economic development of Bangladesh is largely dependent on its agricultural development and this development must have the objectives of increasing agricultural production and increasing labor utilization. The average size of land holdings is very small. Bangladesh has a surplus labor and its land resource is limited. The distribution pattern of farm sizes in Bangladesh is shown in **Table 1.**

Table 1. Percentage distribution of farms and cultivated area according to size group

| Size Group (Acres) | Percentage of farms | Percentage of land cultivated | Ratio |
|---|---|---|---|
| 0.01– 2.49 | 57 | 21 | 0.37 |
| 2.50– 4.99 | 26 | 30 | 1.15 |
| 5.00– 7.49 | 9 | 18 | 2.00 |
| 7.50–12.49 | 5 | 16 | 3.20 |
| 12.50 and above | 3 | 15 | 3.00 |

Source : Government of East Pakistan, Ministry of Agriculture, Master Survey of Agriculture, 1968.

Farm size, labor employment and mechanization have long been a debated issue. Some mechanization experts (A.U. Khan. 1975) believe that mechanization technologies must be developed to meet the requirements of the small farmers in the tropics. The development of mechanization technologies for small farms has been strongly criticized by W. S. Weil. (1976) for the following defects : mechanization technologies of small farm sizes can be helpful for short term, ranging 1-5 years and cannot utilize the potentials of the farmers and the country to the fullest extent. Weil suggests that the living standard of rural population and the economic situation of the country can be improved through : first and foremost, education ; gradual and planned changes of traditional farm and village structure ; planning and follow up of agricultural production ; agricultural processing ; organized purchasing and marketing ; organized services ; creation of additional income sources, etc.

Iftikhar Ahmed (1977) in his paper "Appropriate Rice Production Technology for Bangladesh" suggested that the use of HYV technology in conjunction with bullock can maximize output and employment. He further adds "The use of tractors/power tillers cannot be justified not only on the grounds of displacing labor but also on the grounds of reducing output (or at least not producing any output advantage )". He has also tried to validate his ideas through case studies. The authors fully support the idea of using HYV technology but they do not believe that tractors-/power tillers can be blamed for reduction in production as shown in his case studies. This paper aims i ) to find the relationship between farm size and labor employment for different degree of mechanization, ii) to study the role that farm size plays in modernizing agriculture ; iii) to find the conditions and situations required for exploiting the potentials of the farmers and the conuntry.

## Theoretical Concepts

Meaningful mechanization must increase land and/or labor productivity. Standard of living and per capita income will increase with the increase of labor productivity. Agricultural output Y can be changed by varying the proportions of the land resources A, labor L, and capital C. Labor productivity can be defined as $\frac{Y}{L}$. The increase of $\frac{Y}{L}$ will increase the standard of living and per capita income. Labor productivity can be expressed (P.A. Cowell,

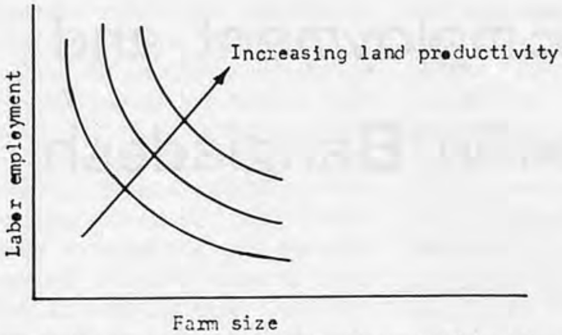

Fig.1 Relationship between labor employment and farm size.

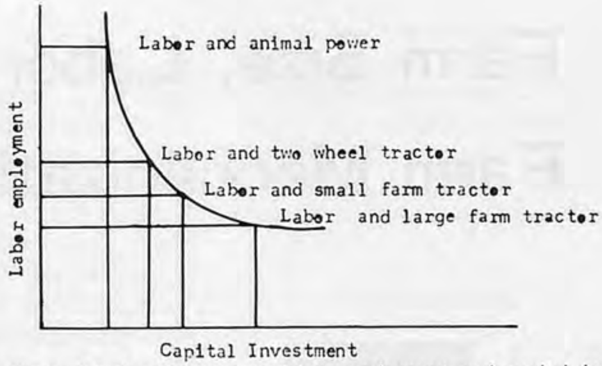

Fig.2 Relationship between labor employment and capital investment

1973 and B.K. Bala, 1978) as Y/L

$$= Y/A \times A/L = \frac{Y}{A} / \frac{L}{A} \quad \cdots\cdots\cdots (1)$$

Where Y/A = Land productivity, yield/acre.

Where L/A = Labor employment, labor/acre.

For developing countries farm size is directly related to labor productivity. Therefore, from equation, (1), farm size FS can be expressed as

$$FS \propto \frac{Y}{A} / \frac{L}{A} \quad \cdots\cdots\cdots (2)$$

$$\text{or } FS = K_1 \left( \frac{Y}{A} / \frac{L}{A} \right) \cdots\cdots (3)$$

Where, $K_1$ = constant of proportionality.

$\frac{Y}{A}$ can be expressed as $\frac{Y}{A}$

$$= \frac{Y}{C} \times \frac{C}{A} \quad \cdots\cdots\cdots (4)$$

Where Y/C = Capital productivity.

Where C/A = Capital intensity.

From equation (3), it is quite clear that farm size is directly related to land productivity and inversely related to labor employment. For constant values of land productivity, the relationships between farm size and labor employment can be represented by a family of hyperbolas as shown in **Fig.1.**

For each constant value of land productivity, there are a number of different combination of farm sizes and labor employment. When farm size is large, labor employment will be less and level of mechanization will be high. When farm size is small, labor employment will be higher and the level of mechanization will cover only crude or intermediate technology. It is important to note from equation (4), that the land productivity can be increased by the introduction of improved varieties and seeds, by use of fertilizers and pesticides. Land productivity can be further increased by better water control and management and multiple cropping in conjunction with seed and fertilizer technology. From **Fig.1** it is quite obvious that land productivity will increase the demand for labor, and both land and labor productivity are influenced by the timelines of operation. Peak labor requirement will make the farmers justify the introduction of agricultural machinery. Labor productivity is desired in agricultural mechanization. Lower labor productivity at the expense of small farm sizes will lower the standard of living of rural population and calls for land reform. Farm sizes are very small in Bangladesh and some people think that small farms should be consolidated for efficient production. Large farm sizes are beneficial if they increase the productivity. According to T.W. Schultz. "The size of farms may change as a consequence of transformation. They may become either larger or smaller—but changes in size are not the source of the economic growth to be had from this modernization process". There are also small farm sizes where productivity is high. Japan is an example.

The equation (1) can be expressed as :

$$\frac{Y}{L} = \frac{Y}{A} / \frac{L}{A} \text{ or } \left( \frac{L}{A} \right) = \frac{Y}{A} / \frac{Y}{L}$$

$$= \frac{\left( \frac{Y}{A} \right)}{\left( \frac{Y}{C} \right) \times \left( \frac{C}{L} \right)}$$

$$\text{or} \left( \frac{L}{A} \right) = \frac{\left( \frac{Y}{A} \right)}{\left( \frac{Y}{C} \right)} \quad \frac{1}{\left( \frac{C}{L} \right)}$$

$$= K_2 \times \frac{1}{\left( \frac{C}{L} \right)} \quad \cdots\cdots\cdots (5)$$

Where $K_2 = \left( \frac{Y}{A} \right) / \left( \frac{Y}{C} \right)$ = Constant and $\frac{C}{L}$ = capital investment.

For constant land productivity and capital productivity, the relationship between labor employment and capital investment is a hyperbola as shown in **Fig.2.** The optimum technology and farm units are determined by means of capital investment. Thus the optimum farm size and technology will change with economic growth.

## Case Studies

### A. Farm Size, Labor Employment and Net Farm Income

Farm size is directly related to land productivity and inversely related to labor employment. For a constant land productivity,

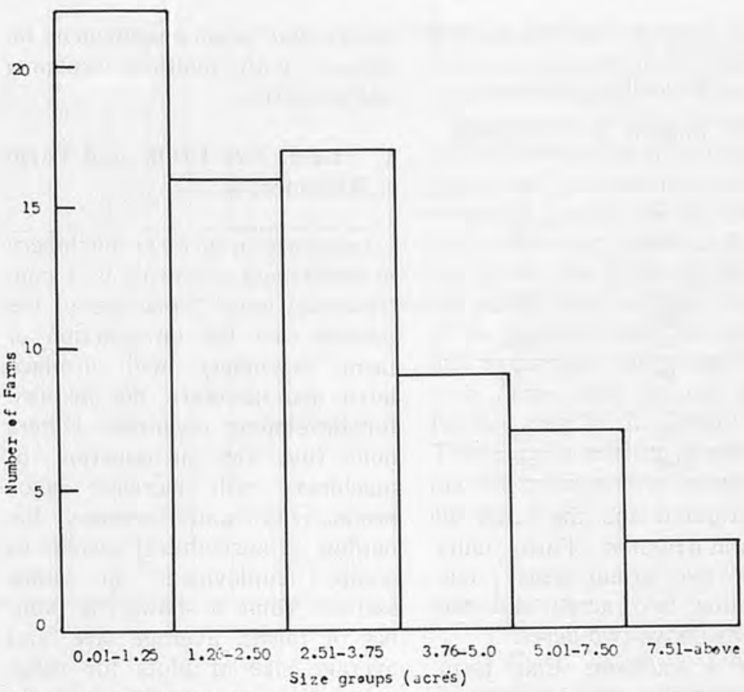


Fig.3 Distribution pattern of farm size

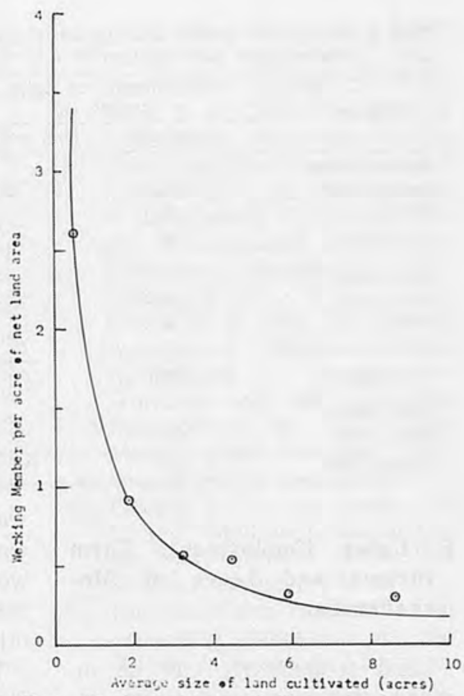


Fig.4 The fitted curve and observations

Table 2.

| Size Groups (Acres) | No. of Farms | Average size of Land cultivated (Acres) | Working Member/ acre of Net Land Area |
|---|---|---|---|
| 0.10−1.25 | 22 | 0.50 | 2.62 |
| 1.26−2.50 | 16 | 1.85 | 0.94 |
| 2.51−3.75 | 17 | 3.22 | 0.56 |
| 3.76−5.00 | 9 | 4.42 | 0.55 |
| 5.01−7.50 | 7 | 5.90 | 0.31 |
| 7.51 and above | 3 | 8.60 | 0.31 |
| All Farms | − | 2.73 | 0.64 |

Source : Islam, Md. Nazrul. Farm Size Efficiency And Effect of Different Inputs on Farm Income In a Selected Area of Bangladesh. M.Sc. Ag. Econ. Thesis, 1974.

Table 3.

| Size Group (Acres) | Net Income (Taka) |
|---|---|
| 0.10−1.25 | 90.04 |
| 1.26−2.50 | 143.13 |
| 2.51−3.75 | 242.49 |
| 3.76−5.00 | 50.60 |
| 5.01−7.50 | 176.73 |
| 7.51 and above | 359.05 |

Source : Islam, Md. Nazrul. Farm size efficiency and effect of different inputs on farm income in a selected area of bangladesh. M. Sc. Ag. Econ. Thesis, 1974.

this relationship can be expressed as: $Y=\frac{k}{x}$ ………(6)

Where y
= Labor employment, (Member/Acre)

Where x
= Farm size, (Acre/Farm)

Where k
= Constant.

To test this hypothesis, two selected villages of P.S. Sariakandi, Dist. Bogra, Bangladesh will be considered. The distribution pattern of farm sizes is shown in **Fig.3**. **Table 2** shows the size group, average size of cultivated land and employment.

To find the relationship between farm size and labor employment the data of **Table 2** was fitted to the equation (6). The fitted curve can be expressed as Y = 1.713. The fitted curve and observations are shown in **Fig.4** and this curve is statistically quite significant. **Table 3** shows that net income is highest for farm size 7.51 acres and above, and the next to the highest is 2.51–3.75 acres.

Table 4. Income of a representative farm of an acre in the irrigated and non-irrigated area. (Deep tube-well irrigation).

| Crop | Distribution of Crop acreage (%) | | Farm Income(Taka) | |
|---|---|---|---|---|
| | Irrigated | Non-Irrigated | Irrigated | Non-Irrigated |
| Aman (deshi) | 92 | 74 | 451.37 | 237.77 |
| IR-20 | 7 | − | 66.01 | − |
| Aman session total | 99 | 74 | 517.38 | 237.77 |
| Aus | 20 | 71 | 46.02 | 225.29 |
| IR-8 | 56 | − | 485.32 | − |
| Jus session total | 16 | 26 | 15.16 | 41.04 |
| | 92 | 97 | 546.50 | 266.33 |
| Boro crops[1] | | | | |
| Boro crops[1] | 36 | 20 | 230.42 | 9.73 |
| Boro session total | 36 | 20 | 230.42 | 9.73 |
| Annual total | 227 | 191 | 1,294.30 | 513.83 |

[1] Boro crops include boro paddy for irrigated area hence concider wheat, oil seeds, pulses, sweet potato etc. for non-irrigated area.

Source : Hussain, Mirza Altaf. An economic analysis of the pattern of resource allocation, enterprise combination, labor employment and farm income in farms using alternative technologies in selected area of Sherpur Thana of Mymensingh District, M. Sc. Ag. Econ. Thesis, 1974.

Table 5. Employment of labor in a representative farm of an acre in irrigated an non-irrigated area (cost of irrigation is fixed @ 50 Taka/Acre).

| Crop | Distribution of Crops acreage (%) | | Man Labor Requirement (hours) | |
|---|---|---|---|---|
| | Irrigated | Non-irrigated | Irrigated | Non-irrigated |
| Aman season | | | | |
| Aman (deshi) | 92 | 72 | 419 | 265 |
| IR-20 | 07 | – | 34 | – |
| Total | 99 | 72 | 453 | 265 |
| Aus season | | | | |
| Aus paddy | 20 | 71 | 80 | 208 |
| IR-8 | 56 | – | 332 | – |
| Jute | 16 | 26 | 82 | 116 |
| Total | 92 | 97 | 496 | 324 |
| Boro season | | | | |
| Boro crops[1] | 36 | 20 | 140 | 50 |
| Annual total | 227 | 189 | 1,089 | 639 |

## B. Labor Employment, Farm Income and Lever of Mechanization

Land productivity can be increased by increasing capital intensity in the form of agricultural inputs. This can also be further increased by better water control and management. In addition, labor productivity will also increase with increased land productivity.

To consider the impact of irrigation three villages of P. S. Sherpur, Mymensingh district will be considered. Total number of farms was 60, of which 30 were irrigated and the other 30 were non-irrigated. Farm units were of two group sizes ; one was below two acres and the other was above two acres.

**Table 4** indicates that farm income increases with the level of mechanization. Further, more multiple cropping with irrigation increases employment. **Table 5** shows that labor employment increases with multiple cropping and irrigation.

## C. Yield, Net Profit and Farm Machinery.

Introduction of farm machinery in developing countries is a controversial issue. Some are of the opinion that the introduction of farm machinery will displace labor and therefore, not justified for developing countries. Others hold that the introduction of machinery will increase labor productivity and increase the outflow of agricultural surplus to create employment in other sectors. **Table 5** shows the number of farms, average size, and average size of plots for three power sources namely ; bullock, power tiller and their combination for some selected areas in the districts of Mymensingh and

Table 6. Power sources and coverage

| Source | Average Size (acres) | Number of Farms | Average No. of Plots | Average Size of Plots(acres) |
|---|---|---|---|---|
| Bullock | 7.62 | 13 | 21.38 | 0.36 |
| Power tiller | 8.50 | 14 | 18.64 | 0.42 |
| Combined | 5.25 | 16 | 15.25 | 0.38 |

Source : Main, Md. Shahjahan. A comperative study of the economics of cultivation by bullock and power tiller in the production of transplanted aman saddy in aelected Areas of Bangladesh, M. Sc. Ag. Econ. Thesis, 1972.

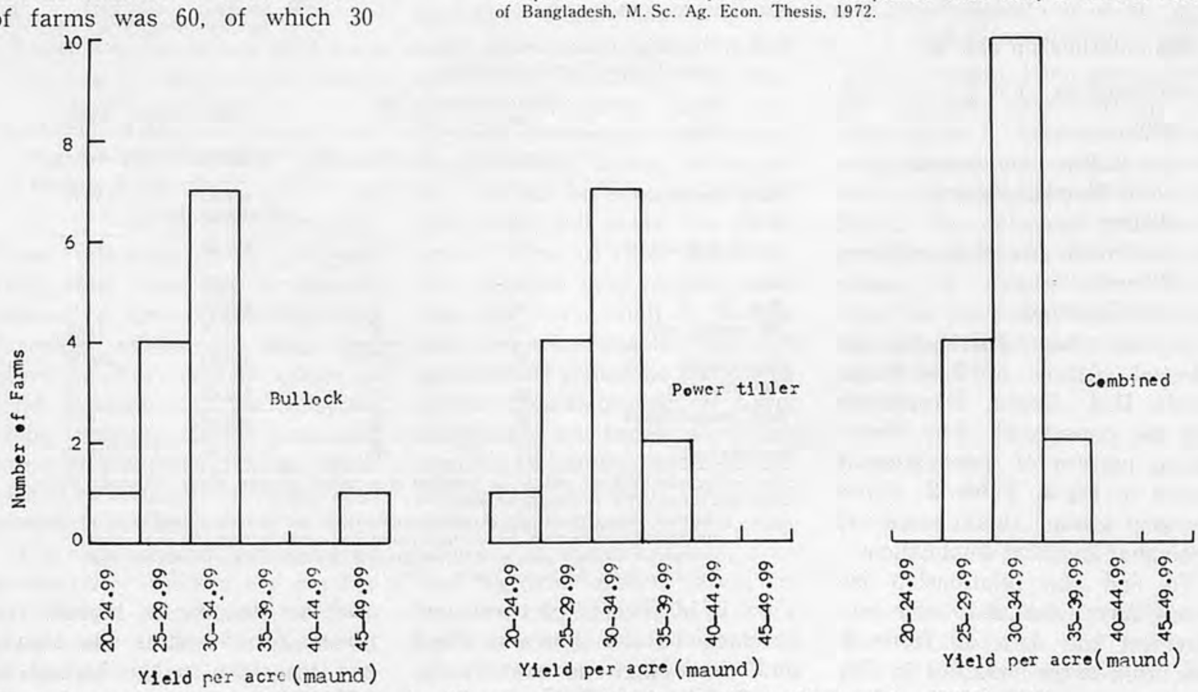


Fig.5 Distribution patterns of yield per acre for different sources of draft power (Note : One maund = 82.286 pounds)

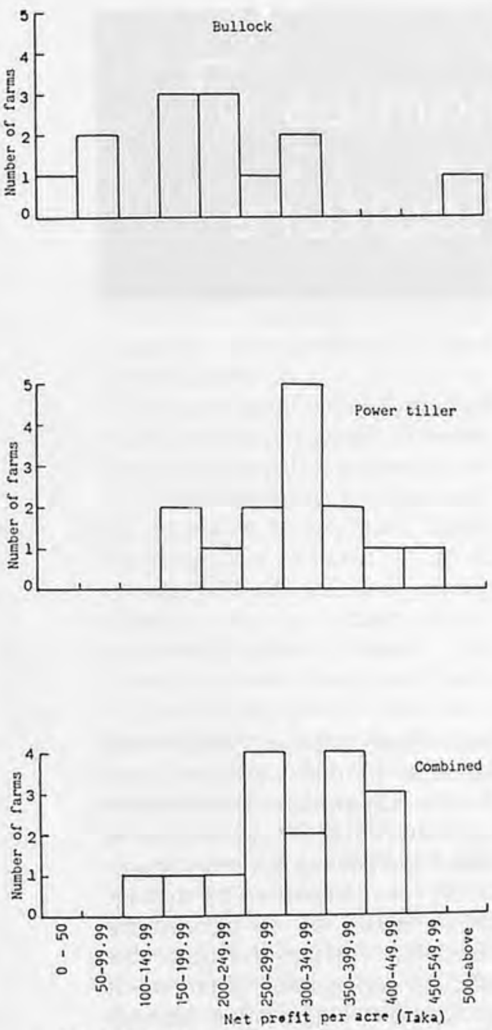


Fig.6 Distribution patterns of net profit per acre for different sources of draft power

Tangail.

**Fig.** 5 shows that the yield per acre is highest for combined bullock and power tiller as draft power.

**Fig.** 6 indicates that net profit per acre is also high for combined bullock and power tiller suggests the desirability of selective mechanization.

The average size of farm under power tiller was comparatively larger than those for either source of power. Fifteen pecent of the farmers purchased power tiller jointly with two partners and the rest purchased and owned them individually in the study area. Half of the farmers reported that their income has increased with the use of power tiller and the rest gave negative answer. Sixty percent of the farmers suggested joint or co-operative use of power tillers.

Coperative farming at Comilla, has demonstrated that the introduction of tractors increases agricultural production. In addition, the co-operative machine farming has shown the potential for both increasing the multipe cropping of the small farmer and allowing him to compete more successfully with large land owners (L. W. Faidley and M. L. Esmay, 1973). This Comilla pattern of operation may be tried in other areas of the country.

## Conclusions

i ) Farm size is inversely related to employment for constant land productivity.

ii) Optimum farm size and technology change with capital investment and economic growth.

iii) Multiple cropping with better irrigation and water management increases land productivity and employment.

iv) Introduction of farm machinery increases land productivity and labor productivity even as it displaces some labor.

v ) Farmers in the study areas have shown interest in machine farming rather than walking behind animals.

vi) Labor productivity can be increased with the introduction of machinery and increasing farm size and these will cause farm capital movement to non-farm sector to provide employment for surplus agricultural labor. Selective mechanization is justified in Baughadesh

## REFERENCES

1. Ahmed, Iftikhar, 1977. Appropriate Rice Production Technology for Bangladesh. AMA Vol. VIII, No. 4 Atumn, pp. 38-44.
2. Bala, B. K., 1978. The Role of Agricultural Machinery in the Developing Countries. Presented at the Third Annual Conference of Bangladesh Association for the Advancement of Science, Chittagong, Bangladesh. Jan. 8-12, pp. 9.
3. Cowell, P. A. 1973. The Role of Agricultural Machinery in Agricultural Development. Workshop on Agro-industrial Development in the lower Mekong Basin, Bangkok, Thailand. 26 No.-18 Dec., pp. 10.
4. Faidley, L. W. and Esmay, M. L., 1973. Multiple Cropping and the Small Farmers. AMA, Vol. IV, No.1, Spring, pp. 62. 65.
5. Hussain. Mirza Altaf, 1974. An Economic Analysis of the Pattern of Resource Allocation, Enterprise Combination, Labor Employment and Farm Income in Farms Using Alternative Technologies in Some Selected Areas of Sherpur Thana of Mymensingh District, M. Sc. Ag. Econ. Thesis, Bangladesh Agricultural University, Mymensingh.
6. Islam, Md. Nazrul, 1974. Farm Size Efficiency And Effect of Different Inputs of Farm Income in a Selected Area of Bangladesh, M. Sc. Ag. Econ. Thesis, Bangladesh Agricultural University, Mymensingh.
7. Khan, A. U., 1975. Mechanization Technology for Tropical Agriculture. AMA Vol. VI. No. 1, Spring pp. 30-37.
8. Mian, Md. Shahjahan, 1972. A Comparative Study of the Economics of Cultivation by Bullock and Power Tiller in the Production of Transplanted Aman Paddy in Selected Areas of Bangladesh, M. Sc. Ag. Econ. Thesis. Bangladesh Agrlcultural University, Mymensingh.
9. Schultz. T. W., 1965. Transforming Traditional Agriculture. Yale University Press, pp. 110.
10. Weil, W. S. 1976. Mechanization of Agriculture in Relation to Development in Developing countries. AMA Vol. VIII, No. 1, Winter. pp. 32-37.

# Economies and Diseconomies of Scale in Malaysian Agriculture

by
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It is generally if indeed not universally, accepted in Malaysia that treecropping, in general, and rubber and oil-palm production in particular, are enterprises appropriate to estate agriculture, while padi-growing is the proper domain of smallholding agriculture. Estates have higher rubber yields than smallholdings ; they account for virtually all the palm-oil output. Padi-growing is practiced only by smallholders. This difference in the emphasis on enterprises as between estates and smallholdings has been recognised at polick-making level from early colonial times and has influenced policy in various ways. It is an important consideration underlying the policy on padi-growing, which regards the attainment of self-sufficiency in rice and the measures directed to that end to a large extent as a means of increasing smallholders' incomes in compensation for their inadequate share in rubber and palm-oil production. Both the superiority of estates in tree-crop enterprises and the superiority of smallholdings in padi-growing need to be challenged.

### Estates and Tree Crops

Economies of scale are normally less in agricuiture than in manufacturing. Tree-crop agriculture, especially, has few economies of scale. The labour required to tap 1,000 rubber trees is approximately ten times as much as that required to tap 100 trees. Labour and other resources to perform a given husbandry operation on a 1,000 acre tree-crop holding is approximately 1,000 times as great as those needed on a 1 acre holding. There are scale economies to be realised at the collection and processing stages, but smallholders can get the benefit of these by using services provided cooperatively or by public agences like RISDA.

The superiority of estates in tree crop production, as reflected in higher yields, more rapid expansion and a larger share of the output, stems from their ability to mobilise and to use effectively the large capital on which tree crop enterprises are peculiarly dependent. Estates are functionally specialised ; they divorce ownership from management and both from labour. They can mobilise in this way for exceptionally capital-intensive forms of agriculture the savings of persons who have not the aptitude, opportunity or inclination to manage or to labour at an agricultural enterprise. Estates facilitate the efficient combination of factors of production. They enable, through the stock exchange, savers to invest or disinrest at will ; they have evolved, through rigorous selection, an efficient managenent hierarchy ; through various incentives and disincentives, reinforced by a large reserve army of unemployed, they maintain an efficient labour force. Estates, because of their ability to mobilise capital and to use it effectively, are superior to capital-strved smallholdings in agricultural enterprises which are exceptionally capital-intensive, as most tree-crops are.

Estate agriculture, producing commodities cheaply and profitably, is peculiarly appropriate to colonialism. It provides for the metropolitan country low cost commodities and, simultaneously, a profitable outlet for surplus capital and for surplus manufactured goods.

Economies of scale in agriculture do not usually outweigh the inefficiencies of centralized management, so that the one-family farm is, in most cases, the most efficient farm firm. Estates prosper under exceptional conditions which, in addition to engagement in exceptionally capital-intensire enterprises, normally also include a labour force held docile by a colonial power.

The passing of colonialism puts estate agriculture under pressure. Popularly based gorernments in sovereign countries are less willing and able to maintain labour discipline on estates ; rapid growth of trade unionism among estate workers is a characteristic of most former colonies. The growth of trade union power under native government can, to a limited extent in estate agriculture, be offset by investment and technological innovation of a labour-saving nature. This makes it possible for estates to pay trade union wages to a smaller labour force, securing their solvency at the expense of society, which is forced to maintain the disemployed workers, who join an existing and already increasing supply of surplus workers.

The ability of estates, which do not enjoy manufacturing industry's economies of scale, to pay trade-union-determined wages is limited. Estate agriculture, as a result, has been losing its market share in the postcolonial era. Estate-dominated sugar production in the former British West Indian Federation has been losing ground to smallholder producers of cane and beet sugar in other countries. Production there declined from an annual average of 823,000 tons in 1956-58 to 699,000 tons in 1973-75, while annual world sugar produation increased from 44.8 m. tons to 78.5 m. tons during the same period. (1. FAO. 1959 and 1975). The share of Malaysia's estate-dominated industry in the world rubber market declined from 31 per cent in 1950 to 15 per cent in 1975, (2. International Rubber Study Group) the loss of market share in this case being to synthetic rubber manufacturers enjoying manufacturing's economies of scale, which are not available to estate producers.

Proposals have been made for mobilising capital for its efficient use by Malaysian smallholder tree-crop farmers. (3. A. Crotty, 1978). An effective combination of inexpensive and efficient smallholder labour and capital promises to increase out-put at lower cost and to increase employment at higher incomes. than are now generally available in rural Malaysia. The proposals involve the replacement of estate agriculture, which is increasingly anachronistic in the post-colonial era, by a smallholding agriculture, supported by appropriate institutional arrangements for supplying. and ensuring the efficient use of the large capital required for tree-cropping.

## Smallholdings and Padi-Growing

Traditional Malay smallholder padi-growing, located in riverine areas subject to periodic inundations, is unproductive. Adequate for a small, stable population, it has been chronically unable to meet the needs of a rapidly expanding population. This became most painfully obvious during the Second World War, but the spectre of cereal shortages has persisted. Malaysia, located in one of the great grain-deficit regions of the world, continues to import large quantities of grain.

Malaysia's grain deficits persist notwithstanding major efforts to expand local production. These efforts include especially the provision of irrigation facilities, which have enabled most traditional padi-growing locations to switch to double-cropping. Extension, credit and marketing services have also been provided.

**Table 1.** Malaysian Rice Production and Net Cereal Inports, 1966-1973

| Year | Rice Production (000 tons) | Net Cereal Imports. (000 tons) |
|---|---|---|
| 1966 | 667 | 610 |
| 1967 | 659 | 709 |
| 1968 | 780 | 798 |
| 1969 | 867 | 722 |
| 1970 | 915 | 796 |
| 1971 | 989 | 665 |
| 1972 | 1,002 | 670 |
| 1973 | 1,106 | 765 |
| 1974 | 1,164 | 844 |

Note : "Cereals" are all items included in the S. I. T. C. codes 041000 to 048300.
Source : Malaysia Department of Statistics, Erternal Trade Statistics, annually 1973 ; and Monthly Statistical Bulletin, June. 1975.

**Table 2.** Area of Padi Planted ('000 acres)

| Item | Wet Padi Main season | Wet Padi Off season |
|---|---|---|
| Average 1965/66 to 1969/70 | 913 | 210 |
| Average 1970/71 to 1974/75 | 913 | 509 |

Source : Departcent of Stattistics, Monthly Statistical Bulletin of West Malaysia June. 1976, Kuala Lunpur.

Double-cropping, while making possible a very considerable expansion in grain production, has also made explicit serious limitation in traditional smallholder methods of production. These limitations arise from the slowness of the methods and the problems this causes in adhering to a tight double-cropping schedule. There was, with traditional single-cropping, a lag of about 150 days from the harvesting of one crop to the planting of the succeeding one. The maturation period for quick-maturing varieties used in Malaysia for double cropping is from 120 to 150 days. Allowing five days for planting and ten for harvesting, the maximum lag between the completion of harvesting and the commencement of planting consistent with double-cropping is around 30 days, or a fifth of the time lag between crops with single-cropping. Land, therefore, has to be prepared for crops twice annually in a shorter total time and by draft animals that are deprived of the nutritous grazing which they used to get

**Table 3.** Summary of Survey Results on Use of Labour in Padi Production, Malaysia

| Location | Padi Acreage per Farm | Family Workers per Farm | All Operations: Man-days per Acre | All Operations: of which Hired(%) | Harvesting: Man-days per Acre | Harvesting: Of which Hired(%) |
|---|---|---|---|---|---|---|
| Province Wellesley | na | na | 33.8 | 55.0 | 14.5 | 75.9 |
| Kemubu | na | na | 39.5 | 12.9 | 10.7 | 18.7 |
| Malacca north | 1.3 | 1.7 | na | 16.2 | na | na |
| Malacca south | 1.6 | 1.3 | na | 9.7 | na | na |
| Malacca central | 3.5 | 3.0 | na | 37.4 | na | na |
| Sungai Manik | 3.2 | 3.8 | 27.4 | 13.5 | 8.2 | 29.3 |
| Seberang Perak Stage I. | | | | | | |
| a) Total sample | 2.8 | 2.6 | 29.2 | 22.6 | 10.1 | 29.7 |
| b) Sub-sample | 3.4 | 2.6 | 24.9 | 33.7 | 9.3 | 68.8 |

Source: Various Reports by Ministry of Agriculture and Cooperatives, 1967–1975.

**Table 4.** Production costs on 2-and 5-acre Padi Lots on a FELCRA scheme in Southwest Perak in 1975.

| Cost Items | 2 Acres $ | 5 Acres $ |
|---|---|---|
| Seeds, fertilizers and insecticides | 136 | 340 |
| Quit rent and water rent | 6 | 15 |
| Nursery work | 7 | 18 |
| Land preparation* | 40 | 235 |
| Transplanting | 8 | 200 |
| Weeding | 6 | 15 |
| Harvesting and bagging | 15 | 550 |
| Field transport | 40 | 100 |
| Zakat (religous toll) | 100 | 250 |
| Total | 358 | 1,723 |

Marginal cost per acre: $\frac{1,723-358}{3} = \$\ 455$

* Land preparation on two-acre plots are assumed to be made by family labour, using draft buffaloes. The actual hire-cost of tractors is taken for five-acre lots. Family labour is charged at $ 1.50 per hour.

from stubble-grazing. This accounts in part, at least, for the decline in buffalo stocks in Malaysia and other South East Asian countries (4. R. Crotty).

Other operations have also to be performed more expeditously. Harvesting, which normally lasted from February to May in Tanjong Karang in the State of Selangor prior to the introduction of double-cropping, has now to be concentrated into February-/March for the main season and for the off-season crop into October, a month with one of the highest average rainfalls. (5. Narkwasdi and Selvadurai). Double-cropping thus requires twice as much padi to be harvested in little over half the har vesting days.

The severity of the constraints of seasonal labour shortages on double-cropped padi using traditional methods is evidenced by the heavy reliance on hired labour **(Table 3)**.

The most common form of payment for harvest labour in Malaysia is the "10-2" system. That is, of every 10 bags of padi harvested, the harvesters get two. It was observed by the writer in southwest Perak State in 1975 that the proportion taken by hired harvesters rose to 30 per cent where the crop was light. The cost of harvesting cereals mechanically in temperate countries, by contrast, normally does not exceed 5 per cent of the value of the crop.

The need to hire expensive off-farm facilities to adhere to a double-cropping schedule with smallholder padi-growing technology causes the marginal cost of padi production to rise sharply beyond about two acres per holding. **Table** 4 shows the costs of growing padi on 2 and 5 acre padi lots on a FELCRA scheme in Southwest Perak in 1975, as indicated by the Manager.

The marginal cost of padi-growing rises sharply on lots over about two acres and approaches or exceeds the value of the crop on five-acre lots.

Seasonal labour and draft-power shortages rather than the shortage of irrigated land can, with double-cropping, be the effective constraint on padi production. Though the irrigated acreage available for main and off-season padi production has been increasing consistently in all Malaysian States, of the 220 observations of main and off season padi acreages for Peninsular Malaysia's eleven States over the decade, 1965/66 to 1974/75, 50 register declines on the acreage planted in the preceding year. That is, in nearly 23 per cent of cases, the State acreages of padi planted were less than in the preceding year, though the acreage available for planting was in all cases at least as great. In the virtual absence of rotations on padi-land, it is clear that substantial acreages of irrigated padi land fail frequently to get planted and are left idle.

Smallholders in Southwest Perak who, in 1968, were allocated five-acre lots of drained and irrigated swamp forest and a subsidy of $80 per acre for clearing the land for padi-growing, in all cases cleared the land and collected the full subsidy, but in no case levelled more than three acres, which appears to be the maximum area of double-cropped padi land which an individual can handle profitably with existing smallholder technology.

Part of this area was subsequently further developed by FELCRA, which levelled all the land, put it under cultivation and returned it to the original allottees. FELCRA's manager on the scheme reported (6. Private) that the grantees were sub-letting cleared lots in excess of the 2 acres which they could operate profitably.

Adherence to a double-cropping schedule may, in these circumstances, reduce output. If existing labour and draft facilities are insufficient to double-crop all the land, production can be increased by reverting to single-cropping, which allows the land to be occupied for a longer period by a slow-maturing, heavier yielding variety. The labour and draft bottlenecks can be widened by allowing operations to be carried out over protracted periods. However, while post-hoc the reversion to single-cropping may be warranted when there is insufficient labour and draft power to cope with the seasonal peak requirements of double-cropping, the capital cost of irrigation for single-cropping is likely to be, ante-hoc, prohibitively expensive.

These problems may worsen in time as, to meet expanding grain requirements, more new areas, like Southwest Perak, are irrigated for padi-growing. Large numbers of smallholders will need to be moved to these areas. If some irrigated land is unworked, or only partly worked now, the new lands will be fully cultivated only if rural incomes are reduced to force more people to migrate to the new areas, or padi-prices are raised to induce them to do so.

Using smallholder technology, increasing labour costs with double-cropping or increasing capital costs with single-cropping, will make it difficult for Malaysia to meet its expanding cereal requirements. A large and growing labour surplus, with possibly declining incomes, as now exists in at least parts of rural Malaysia, may, nevertheless, cause smallholdings to be the most efficient producers of the country's padi requirements. But measures which mobilise capital for, and cause its efficient use by, smallholder tree-croppers, will raise the value of smallholder labour. These measures, if successfully implemented, will therefore raise the cost of padi produced by traditional methods. It is in this context that it becomes relevant to consider alternative methods of production.

### Advantages of Mechanization

Grain-growing is an agricultural enterprise that lends itself peculiarly well to mechanisation. Mechanization enables tasks to be performed more expeditiously, more timely, and, frequently, better. Moreover, double-cropping, which causes difficulties with traditional padi-growing methods, enchances the attractions of mechanisation. It permits seasonal equipment, like ploughs, drills and harvesters, to be used twice as intensely and thus halves their capital cost, which is frequently the principal cost in mechanised cereal-growing. Well paid, skilled operators can also be employed more fully and more effectively when double-cropping is practised.

Some mechanisation of smallholder padi-growing has occured in Malaysia, mainly in the form of tractorised ploughing and cultivations. This has relieved the draft problem referred to and has expedited cultivations. It has, however, realised few of the economies of scale attainable with mechanised grain production. Tractors that are small enough to operate efficently in small padi-fields are less efficient sources of draft power than large ones, but large tractors that are efficient sources of draft power work inefficiently in small fields where an unduly large proportion of their time is spent turning on, and impacting headlands, and where impacted headlands represent an unacceptably high proportion of the total area. Much grain-growing equipment cannot be, or has not been, effectively adapted for operation on small padi fields. Grain harvesters are a case in point, and harvesting is an increasingly severe constraint on smallholding padi-production. The realisation of the benefits of mechanised grain production in large measure depends, like the realisation of the benefits of steam-power in manufacturing, on reorganising production from small to large scale; few of the benefits of mechanisation can be realised in small padi fields, just as few of the benefits of steam power were realised by cottage industries.

Large scale production, as well as being conducive to the efficient use of the machinery which has exceptional advantages when land is double-cropped, has other important attractions for irrigated padi-growing. Efficient synchronising of cultivation, irrigation and drainage is more likely when all operations are controlled by a single firm than when cultivation is carried out by many small firms and the crucially important irrigation and drainage services are supplied by a different organisation. The pests and diseases to which double-cropped padi in the rain-forest tropics appears to be peculiarly prone, are likely to be better controlled by a few large firms than by a multiplicity of small ones. There will, for example, be fewer bunds to shelter rats on large padi fields. The prevention of rat infestation from the periphery is more economical for large growers for whom the periphery is shorter relative to the area worked than for the small grower. Again, for example, the large grower can use aerial spraying for disease and pest control, when this would be impractical for small growers.

### A Feasibility Study of Small and Large Scale Padi Growing

The foregoing considerations underly a studv of the feasibility of two alternative ways of developing for padi-growing 19,000 acres of swamp forest on the west bank of the River Perak in Southwest Perak. One way, referred to as Alternative A, was by smallholder settlers and the other, referred to as Alternative B, was as a single, large scale padi-growing enterprise. Alternative A was conceived on lines which were felt to be most favourable to padi-growing by smallholders on newly settled areas. Bearing in mind the limited padi acreage which numerous surveys suggest can be handled by smallholders, Alternative A envisaged that a further 19,000 acres of available swamp forest, which is out of irrigation command, would be cleared and planted to rubber, oil-palm, cocoa or coconut with a view to providing 9,500 settlers each with 2 acres of padi-land and two acres of crops.

Particulars of both projects are given in **Appendix Tables 1 to 7.**

The indicated investments, internal rates of return (IRR) and the present discounted values (PDV) at 10 percent rate of discount are :

| Item | Investment Required $ mn. | IRR % | PDV $ mn. |
|---|---|---|---|
| Alternative A | 44.6 | 15.0 | 24.144 |
| Alternative B | 11.9 | 46.3 | 90.681 |

The total net revenue from the projects over a 33-year period are $328mn for Alternative A and $449mn for Alternative B. Alternative B would, therefore, be superior even if capital were free.

Alternative A gives more employment than Alternative B. In so far as the level of employment is regarded as a proxy for a preferred, more equitable allocation of income, Alternative A may be preferable in this sense. But employment creation, as distinct from the the income-distribution associated with a given employment level, cannot plausibly be regarded as a policy objective. Using the profits from Alternative B, larger incomes could be given to more people, without requiring them to work or to move from their present places of residence, than if Alternative A were adopted.

The issue does not, however, end there. Alternative B, as noted, requires less capital than Alternative A. A complete comparison of the development of new padi areas by labour-intensive smallholdings or by machinery-intensive large farms must consider also the returns from capital saved by adapting Alternative B instead of Alternative A in the next most productive outlet available. This is done in **Appendix Tables 8 to 11.**

The most productive use for capital in Malaysia after mechanised padi growing, is considered to be rehabilitatind smallholder tree-crops on the lines suggested A Crotty, 1978. Using the same capital over the same period in Alternative B with supplementary "second generation" projects, as in Alternative A, the results are :

| Item | IR % | PDV $ mn. | PDV of Value Added $ mn. |
|---|---|---|---|
| Alternative A | 15.0 | 24.144 | 141.415 |
| Alternative B with "second generation" projects | 24.9 | 125.678 | 244.548 |

Alternative B with second generation projects employs more labour virtually at all stages than Alternative A. It requires, over a 33-year period, on average 5,039 thousand man-days, or 2 times as many as Alternative A, which requires on 2,317 thousand man days annually.

### Conclusion

An effective marriage of capital with smallholder labour for tree-crop production is likely to raise the cost of labour in Malaysia to a level which makes padi production with traditional smallholding technology prohibitively expensive. Large scale mechanised padi-growing is likely, under these circumstances, to be the most efficient means of meeting Malaysia's growing requirements. The efficient organisation of Malaysia's agriculture requires smallholdings to concentrate on tree-cropping and padigrowing to be undertaken by large farms, which is the reverse of the accepted view of the respective roles of small and large firms in Malaysian agricuiture.

## REFERENCES


1. FAO Production Yearbooks, 1959 and 1975.
2. International Rubber Study Group, World Rubber Statistics Handbook, 1946-1970, Vol. 1, and Rubber Statistical Bulletin, Vol. 31, No.3, December, 1976.
3. A. Crotty, "The Rate of Time Discount as a Constraint on Smallholder Tree-cropping", B. A. dissertation, Trinity College, Dublin, Ireland, May, 1978.
4. R. Crotty, Principles of Cattle Economics (In press).
5. U. Narkwasdi and S. Selvadurai, Economic Survey of Padi Production in West Malaysia, (Kuala Lumpur, 1968), pp. 34-5.
6. Private communication, August, 1975.

**Appendix Table 1.** Alternative A: Development of 19,000 Acres of Swamp forest for Padi Growing and 19,000 Acres for Rubber Growing by Smallholders

| | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Number of settlers introduced | | | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 500 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. Land developed for padi, acres | | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 1000 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. Acres of padi grown; single crop equivalent | | | 6000 | 12000 | 18000 | 24000 | 30000 | 36000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 | 38000 |
| 4. Padi development: 2800 acres S 1260; balance S 1500/acre | S000 | 3828 | 4500 | 4500 | 4500 | 4500 | 4500 | 1500 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. Roads, surfaced, 7 miles | S000 | 500 | 500 | 500 | 250 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Road, gravel and earth, 77 miles | S000 | 350 | 350 | 350 | 350 | 1350 | 350 | 450 | 448 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Public cost of introducing settlers | S000 | | 1500 | 1500 | 1500 | 500 | 1500 | 1500 | 500 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. D.I.D. maintenance @ $25/acre | S000 | | 75 | 150 | 225 | 2300 | 375 | 450 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 474 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 | 475 |
| 9. Direct costs of padi-growing @ $ 108/acre | S000 | | 648 | 1296 | 1944 | 6592 | 3240 | 3888 | 4104 | 4104 | 4104 | 4103 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 | 4104 |
| 10. Settlers' maintenance, @ S 1,100/annum | S000 | | 1650 | 3300 | 4950 | 15600 | 8250 | 9900 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 | 10450 |
| 11. Total of above costs (4 to 10) | S000 | 4678 | 9223 | 11596 | 13719 | 12842 | 18215 | 37588 | 15977 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15020 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 | 15029 |
| 12. Padi revenue @ 500 gantangs /acre @ $ 1/gantang | S000 | | 3000 | 6000 | 9000 | −3000 | 15000 | 18000 | 10000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 |
| 13. Net padi revenue | S000 | −4678 | −6223 | −5596 | −4719 | 1842 | −3215 | 412 | 3023 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 39971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 | 3971 |
| 14. Labour available, mandays | 000 | | 390 | 780 | 1170 | 560 | 1950 | 2340 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 | 2470 |
| 15. Labour required for padi @ 30 days/acre, mandays | 000 | | 180 | 360 | 540 | 720 | 900 | 1080 | 1140 | 1140 | 1140 | 1140 | 1140 | 1140 | 1140 | 1140 | 1140 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 | 1100 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 | 1190 |
| 16. Surplus labour (14-15), mandays | 000 | | 210 | 420 | 630 | 19840 | 1050 | 1260 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 | 1330 |
| 17. Land under development for, or growing rubber, acres | | | 2000 | 6000 | 12000 | 000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 | 19000 |
| 18. Mandays required for rubber | 000 | | 160 | 386 | 636 | 870 | 483 | 424 | 546 | 566 | 708 | 955 | 1136 | 1294 | 1363 | 1418 | 1494 | 1556 | 1692 | 1863 | 2015 | 2115 | 1938 | 1858 | 1789 | 1773 | 1768 | 1633 | 1557 | 1480 | 1429 | 1370 | 1257 | 1201 |
| 19. Labour surplus or shortfall (−), (16−18), mandays | 000 | | 50 | 34 | −6 | −30 | 567 | 836 | 784 | 764 | 622 | 375 | 194 | 36 | −33 | −88 | −164 | −226 | −362 | −533 | −685 | −785 | −608 | −528 | −459 | −443 | −438 | −303 | −227 | −150 | −99 | −40 | 73 | 129 |
| 20. Cost of non-settler labour @ $ 4/day | S000 | | | | 24 | 2120 | | | | | | | | | 132 | 352 | 656 | 904 | 1448 | 2132 | 2740 | 3140 | 2432 | 2112 | 1836 | 1772 | 1752 | 1212 | 908 | 600 | 396 | 160 | | |
| 21. Rubber expenses, other than labour | S000 | | 120 | 642 | 1358 | 2330 | 2915 | 2491 | 2734 | 2439 | 2130 | 1843 | 1843 | 1847 | 1855 | 1865 | 1873 | 1863 | 1916 | 2029 | 2203 | 2388 | 2322 | 2294 | 2257 | 2249 | 2244 | 2191 | 2167 | 2148 | 2129 | 2107 | 2076 | 2060 |
| 22. D.I.D. costs on rubber land @ $ /200/acre | S000 | 400 | 800 | 1200 | 1400 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. Total rubber costs (20+21+22) | S000 | 400 | 920 | 1842 | 2782 | 2450 | 2915 | 2491 | 2734 | 2439 | 2130 | 1843 | 1843 | 1847 | 1987 | 2217 | 2529 | 2767 | 3364 | 4161 | 4943 | 5528 | 4754 | 4406 | 4093 | 4021 | 3996 | 3403 | 3075 | 2748 | 2525 | 2267 | 2076 | 2060 |
| 24. Rubber revenue | S000 | | | | | | | | 506 | 1784 | 4044 | 7159 | 9008 | 10369 | 11340 | 12204 | 13382 | 14383 | 16492 | 19136 | 21527 | 23149 | 20555 | 19349 | 18346 | 18177 | 18084 | 16110 | 14968 | 13874 | 13242 | 12530 | 10921 | 10120 |
| 25. Net rubber revenue | S000 | −400 | −920 | −1842 | −2782 | −2450 | −2915 | −2491 | −2228 | −655 | 1914 | 5316 | 7165 | 8522 | 9353 | 9987 | 10853 | 11616 | 13128 | 14975 | 16584 | 17621 | 15801 | 14943 | 15253 | 14156 | 14088 | 12707 | 11893 | 11126 | 10717 | 10263 | 8845 | 8060 |
| 26. Net project revenue (13+25) | S000 | −5078 | −7143 | −7438 | −7501 | −6292 | −6130 | −2079 | 795 | 3316 | 5885 | 9287 | 11136 | 12493 | 13324 | 13958 | 14824 | 15587 | 17099 | 18946 | 20555 | 21592 | 19772 | 18914 | 18224 | 18127 | 18059 | 16678 | 15864 | 15097 | 14688 | 14234 | 12816 | 12031 |

Notes: 1. National average padi yields are assumed.
2. Padi production costs are those reported by the manager of the FELCRA padi-land rehabilitation project in southwest Perak.
3. Settler maintenance and casual labour costs, at S4/day, are slightly less than those reported by FELDA for settler labour.
4. Rubber input/output days are as in Crotty, 1978 except that settler labour is budgetted to cost S/4.23/day, while kampong labour is budgetted to cost S3/day.

**Appendix Table 2.** Alternative B: Development of 19,000 Acres of Swamp Forest for Mechanised Padi-Growing

| Year (1) | DID Development (2) | Land Development (3) | Road Construction (4) | Buildings (5) | Machinery Purchases (6) | Machinery Maintenance, Repairs, etc. (7) | Fuel (8) | DID Maintenance (9) | Salaries and Wages (10) | Seed, Fertilizers and Other Inputs (11) | Total Outlay (12) | Padi Gross Revenue (13) | Net Revenue (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 3190 | | | | | | | | | | 3190 | | −3190 |
| 2. | 1958 | 4042 | 1000 | 110 | | | | 136 | | | 7246 | | −7246 |
| 3. | 2897 | 1944 | 1000 | 110 | 506 | 217 | 66 | 201 | 165 | 738 | 7844 | 6511 | −1333 |
| 4. | 2888 | 2877 | 1000 | 110 | 853 | 322 | 98 | 297 | 210 | 1093 | 9748 | 9643 | −05 |
| 5. | 2888 | 2868 | 1000 | 110 | 1204 | 470 | 145 | 394 | 276 | 1618 | 10973 | 14278 | 3305 |
| 6. | | 2423 | 648 | 110 | 1551 | 616 | 192 | 475 | 360 | 2142 | 8869 | 18898 | 10381 |
| 7. | | | | | 1782 | 726 | 231 | | 416 | 2584 | 6215 | 22800 | 16585 |
| 8. | | | | | 1844 | | | | | | 6277 | | 16523 |
| 9. | | | | | 1847 | | | | | | 6280 | | 16520 |
| 10. | | | | | 1834 | | | | | | 6267 | | 16533 |
| 11. | | | | | 1836 | | | | | | 6269 | | 16531 |
| 12. | | | | | 1815 | | | | | | 6248 | | 16552 |

(Costs and returns are repeated in five-year cycles as in years 8 to 12.)

Notes: Colunns 2, 3, 4 and 5: See Appendix Table 3.
Colunn 6: See Appendix Tables 4, 5 and 6.
Column 7: Taken as 7½% of the purchase price of the machinery in hand.
Column 8: See Appendix Table 7.
Column 9: Taken as S 25/acre/anmna
Columns 10 and 13: See attached note.
Column 11: Costs reported by FELCRA for padi-growing in southwest Perak.

**Notes on Appendix Table 2, Columns 10 and 13.** Salaries and Wages : Staff requirements at full production are :

| | $/Annum |
|---|---|
| 70 tractor operators @ $300/month | : 252,000 |
| 7 foremen tractor operators @ $450/month | : 37,800 |
| 3 executives @ $1,500/month | : 54,000 |
| 1 manager @ $3,000/month | : 36,000 |
| Total of above | : 379,800 |

30 temporary tractor drivers are employed for 1 month during harvesting, at a cost for two seasons, annually, of $36,000. Salaries of mechanics and fitters are included in the item "machinery, maintenance, repairs, etc."

Padi Gross Revenue : Output is assumed to be 600 gantangs/acre @ $1per gantang for each of two crops annually. The assumption of a yield higher than the national average of 500 gantangs/acre rests on :

i ) centralised control of drainage and irrigation services ;
ii ) better, more timely cultivations with high quality equipment ;
iii ) combine drilling of seeds and fertilizers
iv ) centralised control of disease and pests ;
v ) reduced grain losses due to combine harvesting, bulk transport of grain, and centralised drying and storage.

**Appendix Table 3.** Alternative B: Land Development Costs.

Drainage, irrigation, clearing and levelling costs are assumed to be 11 per cent less than for smallholder development. The land would be laid out in 50-acre, instead of 7-acre lots, requiring fewer drainage and irrigation canals.

Roads.

| | |
|---|---|
| Surfaced link road, 7 miles @ S 250,000/mile | : $ 1,750,000 |
| Arterial gravel roads, 18½ miles @ S 125,00/mile | : $ 2,312,500 |
| Other gravel roads, 58½ miles @ S 10,000/mile | : $ 585,000 |
| Total | : $ 4,647,500 |

Buildings.

| | |
|---|---|
| Bulk grain store, workshop, spares and general stores | : $ 450,000 |
| Office and canteen | : $ 100,000 |
| Total | : $ 550,000 |

**Appendix Table 4.** Alternative B: Equipment Requirements

| Equipment | Number | Unit Cost $ | Total Cost $ |
|---|---|---|---|
| Tracked combine harvester, 12 ft. cut | 48 | 90,300 | 4,334,400 |
| Large tractor | 20 | 76,000 | 1,520,000 |
| Mediun-sized tractor | 50 | 26,550 | 1,527,500 |
| Special disc plough | 2 | 4,365 | 8,730 |
| Disc plough | 20 | 5,175 | 103,500 |
| Disc harrow | 17 | 5,670 | 96,390 |
| Scraper/leveller | 16 | 13,410 | 2,141,560 |
| Combine corn-drill | 14 | 15,030 | 210,420 |
| Trailer, 8 ton | 45 | 7,500 | 337,500 |
| Road grader | 5 | 25,000 | 125,000 |
| Land rover | 6 | 15,000 | 90,000 |
| Fans and ducts to aerate stored grain | 10 | 5,000 | 50,000 |
| Total | | | 8,418,000 |

Unit Cost list price, which includes a 5 per cent sales tax and a 4 per cent surcharge on harvesters and trailers, and a 4 per cent surcharge on other equipment.

**Appendix Table 5.** Alternative B: Schedule of Equipment Acquisition

| | Yr.3 | Yr.4 | Yr.5 | Yr.6 | Yr.7 |
|---|---|---|---|---|---|
| Combine harvesters | 14 | 7 | 10 | 10 | 7 |
| Large Tractors | 6 | 3 | 4 | 4 | 3 |
| Medium sized Tractors | 15 | 7 | 10 | 10 | 8 |
| Special Disc Ploughs | 2 | | | | |
| Disc Plough | 6 | 3 | 4 | 4 | 3 |
| Disc Harrows | 5 | 3 | 3 | 4 | 2 |
| Scraper/levellers | 5 | 2 | 4 | 3 | 2 |
| Combine corn-drills | 5 | 2 | 2 | 3 | 7 |
| Trailers | 14 | 6 | 9 | 9 | 1 |
| Road Graders | 2 | 1 | 1 | | 1 |
| Land Rovers | 2 | 1 | 1 | 1 | 1 |
| Fans and Ducts | 3 | 2 | 2 | 2 | 1 |

This schedule is repeated in every subsequent quinquennium

**Appendix Table 6.** Alternative B: Annual Outlay on Machinery Purchases and on Interest on Outstanding Balances

| Year | Machinery Cost $ (1) | Down Payments $ (2) | Subsequent Payments $ (3) | Balance Outstanding $ (4) | Interest $ (5) | Total Payments (2+3+5), less trade-in value $ (6) |
|---|---|---|---|---|---|---|
| 3 | 2,528,780 | 505,756 | | 2,023,024 | | 505,756 |
| 4 | 1,230,365 | 246,073 | 404,605 | 2,602,711 | 202,302 | 852,980 |
| 5 | 1,711,410 | 342,282 | 601,463 | 3,370,376 | 260,271 | 1,204,016 |
| 6 | 1,693,700 | 338,740 | 1 875,289 | 3,850,047 | 337,038 | 1,551,067 |
| 7 | 1,253,745 | 250,749 | 1,146,281 | 3,706,762 | 385,005 | 1,782,035 |
| 8 | 2,528,780 | 505,756 | 1,346,880 | 4,382,906 | 370,676 | 1,843,995 |
| 9 | 1,230,365 | 246,073 | 1,346,880 | 4,020,318 | 438,291 | 1,846,689 |
| 10 | 1,711,410 | 342,282 | 1,346,880 | 4,042,566 | 402,032 | 1,824,483 |
| 11 | 1,693,700 | 338,740 | 1,346,880 | 4,050,646 | 404,257 | 1,835,822 |
| 12 | 1,253,745 | 250,749 | 1,346,880 | 3,706,762 | 405,065 | 1,814,632 |

Payments are made in every subsequent five years according to the years 8 to 12.
20 per cent of the list price is paid on purchase. The balance is paid in 5 equal instalments, with interest at 10 per cent per annum paid on the outstanding balance. All equipment is sold 5 years after purchase and has a trade-in value 15 per cent of purchase price.

**Appendi Table 7.** Alternativo B: Fucl Consumption for 19,000 Acres Padi, Doublc-cropped

| Operation | Days in two seasons | | Hours/ Day | | Gallons/ Hr. | | No. of Units | Fuel per Annum |
|---|---|---|---|---|---|---|---|---|
| Ploughing | 100 | x | 10 | x | 3.5 | x | 20 | 70,000 |
| Discing | 60 | x | 10 | x | 2.5 | x | 16 | 24,000 |
| Plaining/levelling | 60 | x | 10 | x | 2.5 | x | 16 | 24,000 |
| Drilling | 60 | x | 10 | x | 1.8 | x | 14 | 15,120 |
| Combine harvesting | 40 | x | 10 | x | 2.5 | x | 48 | 48,000 |
| Haulage | 40 | x | 10 | x | 2.5 | x | 30 | 30,000 |
| Landrovers, aerating fans, etc. | | | | | | | | 19,000 |
| | | | | | | | | 231,000 |

Cost of fuel: $ 1 per gallon. Cost per annum: $ 231,000

**Appendix Table 8.** Capital Made Available for "Second Generation" Projects by Adopting Large Scale instead of Small Scale Padi-Growing (Uniti'000$)

| Year | Alternative A Capital Requirements | Alternative B: Capital Requirements for Padi | Alternative B: Capital Available for "Second Generation" Projects (1−2) |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | | 3,190 | |
| 2 | 7,143 | 7,246 | −103 |
| 3 | 7,438 | 1,333 | 6,105 |
| 4 | 7,501 | 105 | 7,396 |
| 5 | 6,292 | −3,305 | 9,597 |
| 6 | 6,130 | −10,381 | 16,511 |
| 7 | 2,079 | −16,585 | 18,664 |

**Appendix Table 9.** Alternative B: Net Revenue from "Second Generation" Projects

| Year | Smallholder Rubber Rehabilitation, financed by mechanizing padi-growing (Year of Planting) | Net revenue per acre of rubber by year of planting | Net revenue from rehabilitated smallholder rubber | Alternative B Projects: Net revenue from Padi | Alternative B Projects: Total net revenue padi and rubber |
|---|---|---|---|---|---|
| | acres | $ | $ 000 | $ 000 | $ 000 |
| 1 | 2975 | −300 | −893 | −3190 | −4083 |
| 2 | | −300 | −893 | −7246 | −8139 |
| 3 | 19031 | −133 | −6105 | −1333 | −7438 |
| 4 | 3103 | −254 | −7396 | −105 | −7501 |
| 5 | 18219 | −225 | −9597 | 3305 | −6292 |
| 6 | 17306 | −204 | −16511 | 10381 | −6130 |
| 7 | 19227 | 39 | −18664 | 16585 | −1752 |
| 8 | | 144 | −10850 | 16523 | −327 |
| 9 | | 201 | −10345 | 16520 | 6175 |
| 10 | | 251 | 8886 | 16533 | 7647 |
| 11 | | 265 | 2086 | 16531 | 14445 |
| 12 | | 333 | 5767 | 16552 | 23319 |
| 13 | | 363 | 13806 | 16523 | 30329 |
| 14 | | 392 | 19146 | 16520 | 35666 |
| 15 | | 477 | 22397 | 16533 | 38930 |
| 16 | | 526 | 25630 | 16531 | 42261 |
| 17 | | 890 | 30413 | 16552 | 45965 |
| 18 | | 726 | 33477 | 16523 | 5 000 |
| 19 | | 676 | 43035 | 16520 | 59555 |
| 20 | | 569 | 43646 | 16533 | 60179 |
| 21 | | 510 | 51125 | 16531 | 67655 |
| 22 | | 652 | 53609 | 16552 | 70161 |
| 23 | | 535 | 55055 | 16523 | 71578 |
| 24 | | 488 | 51467 | 16520 | 67987 |
| 25 | | 403 | 45540 | 16533 | 62073 |
| 26 | | 367 | 43684 | 16531 | 60215 |
| 27 | | 421 | 41273 | 16552 | 57825 |
| 28 | | 301 | 39816 | 16523 | 56339 |
| 29 | | 276 | 36046 | 16520 | 52566 |
| 30 | | 241 | 30795 | 16533 | 47328 |
| 31 | | 182 | 28498 | 16531 | 45029 |
| 32 | | 183 | 25813 | 16552 | 42365 |
| 33 | | 208 | 23162 | 16523 | 39685 |

**Appendix Table 10.** Labour Requirements for Alternatives A and B for Alternative B with "Second Generation" Projects

| Year | Mandays/Acre of Rubber/Annum by Year of Planting | Alternative A Padi | Alternative A Rubber | Alternative A Total | Alternative B Padi | Alternative B Rubber | Alternative B Total |
|---|---|---|---|---|---|---|---|
| | | ('000 Mandays) | | | | | |
| 1 | - | - | - | - | - | 238 | 238 |
| 2 | - | 180 | 160 | 340 | - | 98 | 98 |
| 3 | - | 360 | 386 | 746 | 10 | 1558 | 1568 |
| 4 | 32 | 540 | 636 | 1176 | 13 | 971 | 984 |
| 5 | 26 | 720 | 870 | 1590 | 17 | 1866 | 1883 |
| 6 | 22 | 900 | 483 | 1383 | 23 | 2697 | 2720 |
| 7 | 39 | 1080 | 424 | 1504 | 26 | 3038 | 3064 |
| 8 | 48 | 1140 | 546 | 1686 | 〃 | 2067 | 2093 |
| 9 | 64 | 〃 | 566 | 1706 | 〃 | 2259 | 2285 |
| 10 | 69 | 〃 | 708 | 1848 | 〃 | 2706 | 2732 |
| 11 | 70 | 〃 | 955 | 2095 | 〃 | 3166 | 3192 |
| 12 | 76 | 〃 | 1136 | 2276 | 〃 | 3710 | 3736 |
| 13 | 78 | 〃 | 1294 | 2534 | 〃 | 4525 | 4551 |
| 14 | 80 | 〃 | 1363 | 2503 | 〃 | 5189 | 5215 |
| 15 | 87 | 〃 | 1418 | 2558 | 〃 | 5679 | 5705 |
| 16 | 91 | 〃 | 1494 | 2634 | 〃 | 5958 | 5984 |
| 17 | 123 | 〃 | 1556 | 2693 | 〃 | 6352 | 6378 |
| 18 | 108 | 〃 | 1692 | 2832 | 〃 | 6592 | 6618 |
| 19 | 104 | 〃 | 1863 | 3003 | 〃 | 7402 | 7428 |
| 20 | 95 | 〃 | 2015 | 3155 | 〃 | 7421 | 7447 |
| 21 | 89 | 〃 | 2115 | 3255 | 〃 | 8068 | 8094 |
| 22 | 102 | 〃 | 1938 | 3078 | 〃 | 8280 | 8306 |
| 23 | 91 | 〃 | 1858 | 2998 | 〃 | 8388 | 8414 |
| 24 | 87 | 〃 | 1789 | 2929 | 〃 | 8083 | 8109 |
| 25 | 80 | 〃 | 1773 | 2913 | 〃 | 7551 | 7577 |
| 26 | 77 | 〃 | 1768 | 2908 | 〃 | 7392 | 7418 |
| 27 | 80 | 〃 | 1633 | 2773 | 〃 | 7165 | 7191 |
| 28 | 69 | 〃 | 1557 | 2697 | 〃 | 7040 | 7066 |
| 29 | 67 | 〃 | 1480 | 2620 | 〃 | 6674 | 6700 |
| 30 | 64 | 〃 | 1429 | 2569 | 〃 | 6212 | 6238 |
| 31 | 58 | 〃 | 1370 | 2510 | 〃 | 5990 | 6016 |
| 32 | 58 | 〃 | 1257 | 2397 | 〃 | 5721 | 5747 |
| 33 | 70 | 〃 | 1202 | 2341 | 〃 | 5464 | 5490 |

**Appendix Table 11.** Value Added, Alternatives A and B

| Year | Per Acre of Smallholder Rubber by Year of Planting | | | Total Value Added, Padi and Rubber | |
|---|---|---|---|---|---|
| | Materials purchased $ | Gross output $ | Value added $ | Alternative A $ 000 | Alternative B $ 000 |
| 1 | 12 | | −12 | | −36 |
| 2 | 94 | | −94 | −24 | −280 |
| 3 | 81 | | −81 | 2356 | 4623 |
| 4 | 101 | | −101 | 4574 | 5311 |
| 5 | 86 | | −86 | 6602 | 8768 |
| 6 | 86 | | −86 | 8648 | 10563 |
| 7 | 45 | 253 | 208 | 11271 | 14801 |
| 8 | 45 | 386 | 341 | 14401 | 13248 |
| 9 | 45 | 491 | 446 | 16812 | 19679 |
| 10 | 45 | 554 | 509 | 19318 | 22926 |
| 11 | 45 | 572 | 527 | 22720 | 31035 |
| 12 | 47 | 660 | 613 | 24569 | 35239 |
| 13 | 47 | 695 | 648 | 25926 | 43446 |
| 14 | 46 | 730 | 684 | 26889 | 48951 |
| 15 | 46 | 836 | 790 | 27743 | 52546 |
| 16 | 45 | 897 | 852 | 28911 | 56302 |
| 17 | 78 | 1389 | 1311 | 29920 | 60781 |
| 18 | 72 | 1173 | 1101 | 31974 | 63974 |
| 19 | 72 | 1111 | 1039 | 34504 | 75321 |
| 20 | 67 | 972 | 905 | 36728 | 74172 |
| 21 | 65 | 895 | 830 | 38165 | 82518 |
| 22 | 70 | 1080 | 1010 | 35637 | 77677 |
| 23 | 65 | 926 | 861 | 34459 | 83087 |
| 24 | 63 | 864 | 801 | 33493 | 79622 |
| 25 | 62 | 756 | 694 | 33332 | 74468 |
| 26 | 61 | 710 | 649 | 33244 | 73433 |
| 27 | 61 | 772 | 711 | 31323 | 67238 |
| 28 | 58 | 617 | 559 | 30205 | 67965 |
| 29 | 58 | 586 | 528 | 29130 | 64099 |
| 30 | 56 | 540 | 484 | 28517 | 59294 |
| 31 | 55 | 463 | 408 | 27827 | 57079 |
| 32 | 55 | 463 | 408 | 26249 | 52511 |
| 33 | 56 | 525 | 469 | 25464 | 51737 |

**Appendix Table 11. Explanatory Notes**

1. Smallholder rubber, materials purchased : As in Lim Seu Ching and Chong Kow Ming, "Merits of estate participation and incentive wage system in public sector land development", Kajian Ekonomi Malaysia, Vol.XI No.1. An additional $12 of "miscellaneous costs" in Lim and Chong are assuned to be in respect of purchased materials.
2. Value added, smallholder padi : Gross output less cost of seed, fertilizers and insecticides, $68/acre. (Page 5. above)
3. Value added. mechanised padi : Gross output less cost of materials, fuel, machinery purchases (including interest on outstanding debt), and half the cost of machinery maintenance.
4. Value added by rubber in any year (VAR) :
The value added per acre of smallholder rubber in any year, i, (values 1 to 33) is rr, and is given in Column 3. Recalling the rubber planting schedules as :

| Year. | Alternative A (acres) | Alternative B (acres) |
|---|---|---|
| 1 | | 2975 |
| 2 | 2000 | |
| 3 | 4000 | 19031 |
| 4 | 6000 | 3103 |
| 5 | 7000 | 18219 |
| 6 | | 17306 |
| 7 | | 19227 |

$VAR_i$ (the total value added by rubber in year i) is for Alternative A:

$$\$\ 1{,}000\ (2nr_{i-1} + 4nr_{i-2} + 6nr_{i-3} + 7nr_{i-4})$$

and for Alternative B:

$$\$\ 1{,}000\ (2.98nr_i + 19.0nr_{i-2} + 3.1nr_{i-3} + 18.2nr_{i-4} + 17.3nr_{i-5} + 19.2nr_{i-6})$$

# Guidelines for Agricultural Mechanization in Northern Thailand

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### Introduction

Northern Thailand in this article covers the eight provinces of Chiang Mai, Chiang Rai, Lamphoon, Lampang, Phrae, Nan, Mae Hong Son and Tak. The total area is about 65.6 million rai* (105,093 square kilometres) which can be divided into tree main land forms : 40 million rai of highlands, 19.8 million rai of Uplands and 5.8 million rai of lowlands. About 1.6 million rai are at present under irrigation (2). Single cropping is commonly practised in the area. The total population in 1973 was 4,158,855 (3). The climate is tropical wet and dry. The rainy season starts normally in the middle of May and ends at the end of October. The average annual rainfall ranges from 950 to 2,000 mm in the lowlands and unlands. About 85% of the total precipitation falls during the rainy season. The temperature regime is suited for crop growth throughout the year with favourable conditions for cultivation of some temperate crops in the cool and dry season. A growing group of farmers practice the slash-and-burn technology (shifting cultivation). These farmers are non-Thai ethnic groups and an increasingly large number of Thai who are forced into the hills by population pressure in the valleys. The number of the non-Thai hill dwellers is estimated at about 400,000.

### The Present Situation

The northern Thai farmers are facing at least one of the following problems (4) :

- their farm size is too small to support their family ;
- there is lack of sufficient irrigation water ;
- there is a need for cheap and easily obtainable credits ;
- although the individual farmer has labour peaks certain periods, in general, there is a lack of productive employment possibilities.

There is a fairly large number of farmers with less than 10 rai**.

Especially those small farmers who are mono-cropping (maily due to lack of irrigation water) are living on a subsistence level. There are even many farmers who have to buy supplementary food to feed their family. Subsistence farming means often (also due to lack of sufficient job opportunities outside their own farm) lack of cash income. Lack of sufficient cash income makes it impossible to apply improved farm inputs which are necessary for a more productive form of agriculture. Higher price for agricultural products by-pass the subsistence farmer also because he is not producing for a market. This means that in the process of agricultural modernisation the subsistence farmer is most likely to become landless. As the following paragraph will show, it is not yet likely that these landless farmers will be able to find other productive job opportunities in (Northern) Thailand.

Although it is not easy to find exact figures about under-employment in Thailand, the problem is already well recognised. The prevailing mono-cropping system is mainly responsible for this. Seasonal fluctuations are very high and about 25% of the

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* 1 rai-1600m²

** A survey shows that in the Chiang Mai Valley 2.2% of the farm households have less than 5 rai of land while 64.7% had less than 10 rai (5).

**Table 1** Seasonal Rural Employment Pattern in Purely Agricultural Activity by Regions

Percentage of agricultural labour force without work or fully employed

| Month | Northeast (1968) | | North (1969) | | South (1970) | |
|---|---|---|---|---|---|---|
| | (a)* | (b)** | (a)* | (b)** | (a)* | (b)** |
| June | 13.9 | 14.0 | 11.4 | 17.4 | 8.1 | 27.6 |
| July | 10.1 | 11.5 | 8.1 | 16.4 | 5.4 | 18.2 |
| August | 9.6 | 12.7 | 14.8 | 20.7 | 5.2 | 16.7 |
| September | 16.6 | 14.9 | 24.3 | 32.7 | 4.2 | 22.1 |
| October | 25.8 | 16.8 | 27.6 | 32.7 | 7.2 | 29.8 |
| November | 14.9 | 12.8 | 18.8 | 20.5 | 16.9 | 30.6 |
| December | 8.7 | 10.4 | 10.0 | 15.9 | 22.1 | 36.9 |
| January | 15.6 | 14.2 | 16.8 | 19.5 | 17.5 | 34.4 |
| February | 38.2 | 20.4 | 32.7 | 25.1 | 7.7 | 20.9 |
| March | 48.3 | 15.6 | 49.2 | 24.7 | 4.7 | 24.5 |
| April | 47.5 | 16.3 | 51.7 | 21.2 | 16.7 | 39.4 |
| May | 9.3 | 12.7 | 30.4 | 24.3 | 9.7 | 39.0 |
| Average | 21.5 | 14.4 | 24.7 | 22.6 | 10.5 | 28.3 |

*(a) = no work  **(b) = not fully employed

Source : Fuhs, F. W. and J. Vingerhoets; "Rural Manpower, Rural Institutions and Rural Employment in Thailand"; Manpower Planning Division; National Economic Development Board; Government of Thailand; 1972.

working time available during the year is not utilized as is shown in **Table 1.**

There might be temporary shortages locally but this seems to be more a problem of labour mobility than of absolute shortages. The unsatisfactory employment situation in (Northern) Thailand will become worse because the labour force is assumed to double in the next 25 years. Industrialisation will not absorb the expected increase of labour force of 400,000 labourers per year. The industrial sector and services absorbed only 34% of the increased labour force from 1960–1969(6). This means that most of the additional workers will have to find productive employment in agriculture. The above explained situation asks for an employment creating development strategy because unused labour forces are not only a loss for the nation but for the people concerned, it means no income and poverty which may cause social unrest. However, increasing employment without regard to its productivity is a wrong approach. Agricultural mechanization is an important possibility to improve the productivity of the labour force.

The population growth in Northern Thailand is estimated at about 2.5%–3%. This creates an increasing population pressure on the already overpopulated lowlands. Increase in land productivity as a result of construction of irrigation works and the introduction of better farming techniques and new technology is certainly possible. However, to feed and employ the increasing population the opening up of new farm land will also be necessary. Northern Thailand has the possibility to expand its agricultural area by developing uplands since the uplands make up about 30% of total area of Northern Thailand and represents areas with suitable slopes and accessibility for agriculture.

The previously explained situation in Northern Thailand asks for a low-cost type of mechanization which increases the agricultural production, creates more employment and improves labour productivity. Different types of mechanization will be needed for wet land and dry land farming.

## Some Aspects of Mechanization, Labour Expenditure and New Agricultural Technology

### Impact of Mechanization on Crop Yield

Farmers and farm management economists are interested in factual and quantitative date on differences in yield that can be expected if farm operations are done with mechanical power and suitable implements, instead of being carried out by hand or animal power with traditional tools and implements.

**Fig.1** Demonstration and Research Farm of NADC for improved upland farm practices. After construction of terraces upland rice is planted on ridges.

Quantitative date of the effects of mechanization on yield can be obtained from field experiments at agricultural research stations, or by measuring yields on fields managed by farmers using either mechanical or traditional methods. Data obtained from farmers' fields are often not comparable because farmers who can afford mechanization may also use more fertilizer, pesticides, insecticides and better seeds than farmers who have only traditional power sources and implements.

In the past, several studies on both research stations and farmers' fields have been carried out in other countries and regions than Northern Thailand. Investigation of these studies led to the conclusion that there is little evidence that the mere substitution of animal power by mechanical power in farm operations can effect a significant increase in crop yields (7). For instance, it is often assumed that the deeper ploughing of tractors is an important explanatory factor for higher yields but several studies have shown that deeper ploughing may also decrease yield.

The availability of mechanical power for high rates of application enables the farmers to use time-tight multiple cropping systems. These multiple cropping systems can result in increased annual production per unit of land area. The same situation might appear by using mechanical power for irrigation purposes. But using more efficient handtools, more animal power, introduction of animal-drawn equipment and other oultural practices might give the same result.

One has to be very careful to describe merely or even partly higher yields as the result of tractorization. A mathematical correlation does not have to be casual. A poorly carried out investigation is able to show that a certain type of mechanization results in higher yields while in fact the reverse is true ; higher yields result in mechanization

Higher yields are certainly not achieved by mechanical power only : fertilizer, insecticides, improved animal-drawn equipment or other new farm practices will result in higher yield, probably against lower social costs and with lower initial cash requirements.

## Impact of Labour Expenditure on Crop Yield

The assumption that there is a relation between labour expenditure and crop yield is acceptable. The farm management economist is interested in the yield increase as a result of the labour increase for different farm jobs (marginal labour productivity). However, it is difficult to quantify this relation. For example, the labour productivity of fertilizing is influenced by the amount and type of fertilizer, the timing of application and the water supply afterwards. The higher yield is often not only the result of labour input but also of management. A certain labour input for a specific task will also affect the labour input later on. For example, fertilizing does not only ask for labour to apply the fertilizer but as a result of the higher yield, it will also affect the labour needed for harvest, threshing and transport. **Table 2** shows the relationship between yield and labour expenditure on some crops in Northern Thailand.

**Table 2** Relationship between Yield and Labour Expenditure on various crops in Sansai (Chiang Mai Province, Northern Thailand)

| N = Sample size | Low yield | Medium yield | High yield |
|---|---|---|---|
| Early rice crop : | N = 12 | N = 28 | N = 16 |
| Mean yield (buckets/rai) | 30.6 | 46.8 | 66.8 |
| Total mandays/rai | 21.71 | 23.19 | 28.48 |
| Late rice crop : | N = 25 | N = 46 | N = 22 |
| Mean yield (buckets/rai) | 12.3 | 26.0 | 48.2 |
| Total mandays/rai | 20.55 | 21.98 | 23.88 |
| | Low input | Medium input | High input |
| Carlio crop : | N = 31 | N = 36 | N = 15 |
| Mean yield (kg/rai) | 418 | 759 | 1440 |
| Total mandays/rai | 53.6 | 61.04 | 80.14 |
| Watermelon crop : | N = 20 | N = 15 | N = 6 |
| Mean yield (fruits/rai) | 631 | 1190 | 2110 |
| Total mandays/rai | 55.36 | 61.05 | 65.51 |

Source : Calavan, M. M. "Decision against nature : Crop choice in a Northern Thai village" ; Ph. D. Anthropology; University of Illinois at Urbana-Champaign; 1974.

Note : The source specifies the labour expenditure for the various tasks per crop.

## Impact of New Agricultural Technology on Employment

The gloomy employment situation in Northern Thailand should raise question whether impyoved or new agricultural techonlogy will increase or decrease the employment possibilities. The most important ingredients of improved agricultural technology are cropping intensity, high yielding varieties, use of fertilizers, insecticides, pesticides and farm mechanization.

Intensive agriculture (multiple cropping and relay cropping) has high potential for providing employment and increase of land productivity in Northern Thailand. The results of a Linear Programming model to derive optimal multiple cropping systems for the Chiang Mai Valley shows in **table 3** the employment potentials for several systems.

In estigations of studies on mechanization shows that tractorization influences the employment of farm labour negatively as is shown in **table 4.**

It is likely that mono-cropping rice farms in Thailand can also employ more labour. Transplanted paddy farming in Japan requires 22.5 man-days per rai. The difference between the figures in **table 4** and Japan is mainly a result of different inputs for weeding, fertilizing and water control (8).

Sometimes studies show that tractorization can create more

**Table 3** Employment Potentials for Several Multiple Cropping Systems

| Farm size 10 rai Cropping System | Family Labour: Used on Farm: Storable Crops | Family Labour: Used on Farm: Vegetable Model | Family Labour: Sold off Farm: Storable Crops | Family Labour: Sold off Farm: Vegetable Model | Labour bought: Storable Crops | Labour bought: Vegetable Model |
|---|---|---|---|---|---|---|
| (Crops/year) | (Index of Man Years*) | | | | | |
| 2 Crop Budgeted** | 131 | 160 | 169 | 140 | 2 | 3 |
| 2 Crop Optimal | 190 | 220 | 110 | 80 | 17 | 11 |
| 2.5 Crop Optimal | 214 | 242 | 86 | 58 | 34 | 46 |
| 3. Crop Optimal | 240 | 263 | 60 | 37 | 29 | 80 |
| Unlimited | 240 | 277 | 60 | 23 | 29 | 119 |

* One man-year(100) equals 313 working days or 2,191 working hours.
** Currently common rice-soybean cropping system.
Source : Alan R. Thodey and Rapeepun Sektheera, "Optimal Multiple Cropping Systems for the Chiang Mai Valley" Agricultural Economics Report No.1; Chiang Mai University; Thailand; July 1969.

Table 4 Labour Requirements for Rice Growing by Operation and Type of Technique (Man-days per Rai)

| Operation | Type of farming techniques* | | | |
|---|---|---|---|---|
| | TB | TT | BB | BT |
| Land preparation(including nursery) | 4.5 | 1.5 | 3.0 | 0.5 |
| Sowing/planting | 3.5 | 3.5 | 0.25 | |
| Care | 1.5 | 1.5 | 1.0 | 1.0 |
| Harvesting and threasing | 4.5 | 4.0 | 4.5 | 4.0 |
| | 14.0 | 10.5 | 8.75 | 5.5 |

TB=Transplanting with buffalo farmings;
TT=Transplanting with tractor farmings.
BB=Broadcasting with buffalo farming;
BT=Broadcasting with tractor farmings;

Source : NEDECO: Project of land consolidation : Phase I (Bangkok, Royal Irrigation Department); Singhburi Province; Central Plain; 1968.

employment opportunities but whether the use of tractors will increase labour requirements or not depends on the possibility of using new farming techniques. Suppose the farmer is preparing his field by buffalo which results is not enough time left for transplanting. By tractor tillage, he is able to change from broadcasting into transplanting. **Table 4** shows that this will increase his labour input with 1.75 man-days rai (20%). Therefore, tractorization results in an increase of labour utilisation because a change of growing technique is possible. However, the real problem in this example is the limited amount of availabie buffaloes. If sufficient buffaloes wers available, the timing problem would not occur and transplanting would be possible. This would increase the labour input by 5.25 mandays/rai (60%) or three times more than tractorization does. This example should emphasize that tractorization might increase employment opportunities if compared with traditional farming practices but intermediate types of mechanization might result in a higher increase.

With the introduction of new agrictural technology it must be avoided that the large tarms are intensifying their operation by large scale mechanization which results in a decline of agricultural labour employment.

## Agricultural Mechanization as a Complementary Input

In order to raise the land productivity in Northern Thailand, modern agricultural production methods are necessary. For this reason, there will be a need for increased power input and improved agricultural tools and equipment complementary to, for instance, multiple cropping technology. However, reasons for mechanization should be studied carefully. Not always is mechanization the best and only solution. The following examples may explain this :

—A classic argument about the introduction of tractors is that the soil is often too hard after the dry season for animal tillage. However, in East Africa, introduction of a mulch-type fallow tillage, which could be carried out by animal traction, proved to be a more appropriate solution than the introduction of tractors (9).

—Labour peaks do not necessarily have to be removed by mechanization. Using varieties with different planting and harvesting times might be a solution as well as a varied cropping pattern. The cultural practice also affects the labour input. Wider spacing will decrease the labour input during planting, weeding and harvesting while the yield does not necessarily have to decrease and might even increase.

—Introduction of different types of animal-drawn equipment can also speed up farm operations. The only animal-drawn equipment available in Northern Thailand is the paddy field plough and comb narrow. Farmers do not know of the existence of animal-drawn equipment such as disc harrows, oultivators, peed drills, and inter-row cultivators.

## Guidelines for Realistic Choices for Northern Thailand

The economy of Northern Thailand is based on agriculture and the Goverment is aiming to improve the level of living of its rural population. It is clear that because of the high rate of under-employment, sophisticated capital intensive western-type mechanization is not appropriate because this type of mechanization is designed mainly to replace expensive human labour. The 5-year plans of the Royal Thai Government mention job creation as an important task and therefore emphasis should be given on a labour-intensive development policy. To solve the problems of labour surplus regions, there is a need for a specific mechanization pattern which is adjusted to the local problems and which fits the socio-economic and agricultural needs of Northern Thailand. Besides that, for a highly sophisticated mechanization programme there is a need for credit, dealers, spare parts' supply, mechanics and skilled operators and it is not likely that this can be acquired quickly in the northern rural areas. There is also the question of "Who gets the Benefits ?". The costs of imported equipment (depreciation) are exported as income to factories in the developed countries, but wages paid to local labourers are spent on locally-produced items which have a positive effect on the national economy.

As explained previously, the mechanization pattern adopted should aim to maximize the productive labour absorption capacity of agriculture and to improve productivity. Especially improved handtools, animal-drawn equipment and 2-wheel tractors can meet these goals. Any form of mechanization which is aiming to displace human labour should be avoided.

A recent survey of buffaloes in Thailand shows that the buffalo

Table 5 Working Periods of Thai Buffaloes

| Zone | Months Worked per year | | Days worked per month | | | | | | | | | | | | Total days per year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Range | Average | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
| North | 2-8 | 3.3 | 0 | 1.1 | 0.9 | 0.7 | 4.3 | 17.3 | 19.3 | 16.1 | 1.8 | 2.9 | 0.7 | 1.1 | 66.1 |
| Korat | 4-12 | 5.6 | 3.9 | 3.9 | 3.9 | 3.9 | 15.2 | 25.2 | 25.9 | 28.3 | 15.0 | 3.9 | 3.9 | 3.9 | 136.9 |
| Tha Pra-Udorn-Ubol | 1-12 | 5.3 | 0.9 | 0.8 | 2.2 | 3.5 | 22.3 | 25.2 | 26.7 | 26.9 | 20.7 | 6.3 | 1.9 | 0.9 | 138.3 |
| Central Plain and southeast | 3-10 | 7.9 | 10.3 | 7.8 | 3.0 | 4.1 | 17.4 | 22.8 | 22.2 | 21.8 | 11.3 | 8.8 | 6.6 | 10.0 | 146.1 |
| Average | — | 5.5 | 3.8 | 3.4 | 2.5 | 3.0 | 14.8 | 22.6 | 23.7 | 23.3 | 12.2 | 5.5 | 3.3 | 4.0 | 122 |

Source : Ros Cockrill, W. (editor), The Husbandry and Health of the Domestic Buffalo. FAO Rome, 1974, pp. 317.

is far from being employed to its fullest capacity (**Table** 5). The same situation exists for most of the cattle. The main reason for this is the mono-cropping of paddy : the animal are only used for preparation of the paddy fields and left idle for the rest of the year.

The tillage of permanent upland fields is mainly done by tractor contractors and hardly any animals are used for this purpose. The main reason for this seems to be that suitable animal-drawn equipment for soil tillage, seeding and inter-row tillage have not been introduced. Introduction of animal powered water lifting devices would employ the animal also during the growing season. The manure could be used for gas production in family size biogas plants to reduce the need for fire wood for cooking.

It is interesting to note that the much-needed animal-drawn equipment and handtools are easy to fabricate in small workshops without the need for complicated technology and big investment. The production of these locally-made tools and equipment is of great importance for the development of small-scale decentralised labour-intensive industry in Northern Thailand.

Fig.2 Thai-made Diesel Tractor with PTO and Hydraulic Lift built from used truck components.

The improvement of the employment possibilities in Northern Thailand should not only be labour-intensive farming techniques. Rural employment programmes should also be strated on land clearing, road construction, terrace-making, construction of irrigation systems and other rural construction actvities especially during the agricultural off-season. Often this work is carried out with expensive imported equipment. The operation of, for instance, a medium size bulldozer with equipment costs at least 500 Baht per hour while a labourer earns about 2.5 Baht per hour. This means that 200 labourers could be hired for the same amount of money. If the bulldozer does the job for a cheaper market price it should be clear that rural employment programmes should be judged by real costs for society. Even if labour intensive programmes results in higher real costs but create more employment (and hence income for low income groups), these higher real costs might be worthwhile to improve income distribution and social equity.

Fig.3 Construction of 2-wheel tractor (so called "Iron Bufealo") in Central Thailand.

In a report by the Manpower Planning Division of the National Economic Development Board (NEDB), recommendations have been made to ensure maximum employment in the rural areas for the fast growing labour force. Recommendations directly concerning agricultural mechanization on are (6) :

—design and implement a selective farm mechanization policy geared to the system of small peasant farmers who are naturally inclined to be very selective in their choice of mechanized farm equipment ;

—put heavy import duties on the import of farm machinery which is not suited for the development of a labour-intensive peasant agriculture ;

—create a central agency dealing with farm mechanization, possibly through a merger of the Rice Engineering and the Farm Machinery Division."

These (and nearly all of the other) recommendations of the above mentioned report are applicable to Northern Thailand and should get full consideration for implementation.

A study on labour-intensive road construction in Chiang Mai province shows that labour-intensive and/or intermediate methods used in the construotion of a typical gravel feeder road are technically close to being socially feasible. If such methods were adopted, approximately 90,000 more man-hours of unskilled labour per kilomether road construction would be required (10). The study will be even more valid now since fuel prices have more than tripled and also equipment prices have been raised considerably. The "Fang River Catchment Development Project" in Chiang Mai province is carried out as a labourintensive project. Experiences and findings from this project should be evaluated carefully and be used for other labour-intensive projects. To improve the productivity of unskilled labour, appropriate handtools, good management and supervision, good nutrition and payment in a piece rate have proved to be very effective.

## REFERENCES


1) Krui Panayasingh, "Role and Responsibilities of the Northern Region Agricultural Development Centre (NADC)", Chiang Mai, 19 May 1976.
2) NADC National Resources Branch, Internal Memorandum, Chiang Mai, 14 June 1976.
3) National Statistical Office, Royal Thai Government, Bangkok, 1973.
4) Rijk, A.G., "Orientation Survey on Employment and Mechanization in the Northern Region", Internal Report, NADC, Chiang Mai, 7 December 1976.
5) Benchavan Tongsiri, Pichit Lerittamrab and Alan R. Thodey, "Agro-Economic Characteristics of the Chiang Mai Valley, 1972-73", Agro. Ec. Report No. 5, Chiang Mai University, Thailand, January 1975.
6) Fuhs, F.W. and J. Vingerhoets, "Rural Manpower, Rural Institutions and Rural Employment in Thailand", Manpower Planning Division, National Economic Development Board, Government of Thailand, Bangkok, 1972.
7) Rijk, A.G., "Policy aspects of Employment and Agricultural Mechanization for the Northern Region of Thailand", Internal Paper, NADC, Chiang Mai, December 1976.
8) Inukai, I., "Farm Mechanization, Output and Labour Input : A case study in Thailand", International Labour Review, May 1970, pp. 453-473.
9) Mc Robie, G. "An approach for appropriate technologists", Lectures on socially appropriate technology, Committee for International Cooperation Activities, Technische Hogeschool, Eindhoven, The Netherlands, 1974.
10) Mc Cleary, W.A., et al. "Equipment Versus Employment", International Labour Organisation, Geneva, 1976, pp. 87-92.


## INDEX TO ADVERTIZERS

# Demand for and Marketing of Domestically Produced Small Farm Tractors in Thailand

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## Introduction

Prior to 1950, the use of farm tractors in Thailand was almost unknown. Farmers relied upon human labor, animal power and a few simple tools. After 1951, farm machines such as tractors and harvesters were introduced into Thailand for use at experiment stations, but these machines did not generate much public interest at that time. Not unitil almost a decade after the second World War did farm machanization become better known to farmers. More tractors were bought for private use as well as for hire, but only a limited number of farmers could afford to buy them. Starting from near zero in 1950, the farm tractor population in Thailand rose to 17,500 units of the four-wheeled tractor and 2,040 units of the two-wheeled tractor in 1967.[1]

Since there was no local manufacturer in Thailand during this early period, and even though some local manufacturers emerged later, there is no legal record of the production, Imports alone reflected the market for tractors. Examination of Thailand' import statistics therefore was made as the first step in the market evaluation. The lists of leading tractor importers are given in **Table 1.** Tractor import statistics by the Customs Department show that farm tractor imports gradually increased from 1963, reached a peak in 1967, and have declined since[2] **(Table 2).** The decline in tractor importation is possible because the Thai farmers have substituted the small local tractors for the expensive imported one. The small locally manufactured tractors are also called "power tillers". So far we can conclude that the small tractors are most suited for the paddy farm, and the use of mechanized equipment in rice farming is now increasing and spreading rapidly.

**Table 1.** Lists of leading Thai imports of farm tractors, farm equipments and parts.

| Company | Brand |
|---|---|
| Anglo-Thai | Ford |
| Louis T. Leonovens | Massey Ferguson |
| Mechanical Equipment Co. Ltd. | International Harvestor |
| John Deere Thailand Ltd. | John Deere |
| Ua Withaya Phanit Co. Ltd. | Nuffield |
| Yip In Tsoi & Jacks Ltd. | David Brown |
| Bara Windson Co. Ltd. | Hanomag |
| CKR Motors Ltd. | Case |
| Minsen Co. Ltd. | Zetor |
| Minsen Machinery Co. Ltd. | M. T. Kubota |
| Thai Machinery Industry Co. Ltd. | Steyr |
| The Mechanized Equipment Co. Ltd. | Valmet |
| Young Teng Sue Co. Ltd. | B. M. Volvo |
| Asian Honda Motor Co. Ltd. | Honda |
| Nichimen Co. Ltd. | Yanmar |
| Nakorn Luang Motor Co. | Iseki |
| Bangkok Motor Works. | KOmatsu |
| Bangkok United Mechanical | Mitsubishi, Hitachi |

Source : Survey 1968 (1, p3)

**Table 2.** Imported tractors (1963 – 1972)

| Year | Amount | Value(baht) |
|---|---|---|
| 1963 | 2,247 | 194,227,197 |
| 1964 | 3,864 | 283,660,136 |
| 1965 | 5,200 | 322,419,302 |
| 1966 | 4,577 | 408,317,130 |
| 1967 | 5,698 | 567,607,388 |
| 1968 | 5,104 | 477,713,352 |
| 1969 | 3,631 | 326,738,986 |
| 1970 | 2,305 | 314,075,816 |
| 1971 | 2,662 | 359,272,414 |
| 1972 | 1,809 | 289,074,652 |
| Total | 37,097 | 3,543,106,273 |

Source : Custom Department.

Like most of the Southeast Asian countries, Thailand has attempted to become more developed, especially in the way of production technology. Unitil now agricultural products have played a significmnt role in the Thai economy. Thai farmers, the "back-bone" of the country, are regarded as the people in the low income group. The reasons for low income are numerous, but the relevant evidence is basically low yield and under utilization of resources. To provide a better standard of living for the rural population, it necessay to increase farm income and productivity of land and labor. In rice cultivation, double cropping techniques have been introduced. They can be more successful perhaps if the conventional farming practices were replaced by improved technology.

In reality, although the introduction of agricultural mechanization provides many good prospects for farm development, there are also many problems. It offers a greater production output and reduces human drudgery. However, if the market cannot absorb the increase in output, and the labor displaced by mechanization cannot find employment elsewhere, then the condition of agriculture is not really improved. Moreover, when machinery has to be imported, problems may be that the machines are too complicated and costly. The way to increase the adoption of agriculture machinery is to assure the farmers that the new technical equipment can provide them with a high income. Recent advances in plant breeding have demonstrated that it is possible to raise the crop yield significantly. The rise in the income of farmers who have adopted new varieties has stimulated the employment of the farm machinery even further.

## Review of Literature

A field survey of the market for farm machineries in Thailand was conducted thoughout all regions of Thailand by a working team from five Thai government agencies in 1968. The survey interviewed . 323 custom service operators, farmers, equipment dealers, importers, manufacturers and assembles. The equipment owners and operators interviewed were selected on a random basis in predetermined provinces to represent the varying agricultural production and practices in all regions. The study divided Thailand into 10 regions and focused on primary sources of mechanical farm power tractors and related auxiliary equipment. There are as many as 27 different brands of farm tractors, imported form 22 countries.

Based on the survey, farm mechanization has grown significantly since 1963. Almost 15 percent of the farm households in Thailand used mechanical power of some sort. It was estimated that tractors were used on over half the paddy fields in the central plains, East and South regions. Tractor use was estimated to reach 80 percent in the Bangkok Metropolitan area. Tractor use in other regions for rice production was found to be small and lowest in East-Northeast where it was estimated to be only 3 percent. The use of tractors expanded farm productivity and was lower in unit cost than hand labor and draft animals. The hourly land tilling capacity of tractors was a minimum of 24 times that of farm labor and draft animals in paddy fields and a minimum of 36 times higher in upland farming. The cost of farm tractor services, according to the study, was found to be lower than the cost of hiring farm labor and draft animals.

## Scope and Objectives

The overall objectives of this paper are to describe and analyze the marketing of small farm tractors that are produced in Thailand. Marketing is used in the broad sense ; namely, all aspects of the movement of products from the producers to the final consumers. In this case, the producers are the firms thich manufacture the small two-wheel and four-wheel tractors in Thailand, and the consumers are the Thai farmers who purchase these tractors.

## Procedure

The general procedure followed in this study is that of tracing the marketing channels for small tractors from two directions ; namely, from producers to farmers and then from farmers back to the producing firms. The research started with a survey of all firms in the Central Plain. Some firms then deliberately selected for studying the firm-to-farmer links. Then two rice producing areas, Supanburi and Chachengsao, were selected for studying the farmer-to-firm links.

## Marketing of Small Tractors from the Viewpoint of Firm

### The Initial Industry-Wide Survey

In order to conduct a sample survey of the farm machinery manufactring firms for her research, Waranya Rewan[3] spent considerable time and effort in constructing a consolidated list frame. Names and addresses of firms were obtained from the following four sources : Division of Factory Control ; Ministry of Industry Department of Labor ; Ministry of Interior ; Division of Commercial Registration, Ministry of Commerce and Division of Agricultural Engineering, Ministry of Agriculture and Cooperatives.

These government offices keep the lists of these firms for various reasons, such as requirements for factory registration, labor law enforcement, etc. Thousands of names were listed, hence each list which was thought to be somehow associated with production of agricultural machines had to be inspected.

The lists were re-examined and a final list frame was prepared. About 270 firms in 26 provinces in the Central Region were thought to be manufacturing agricutural implements, but field investigation showed that the list was inacurate. Hence the procedure changed to using informants consisting of managers of the firms themselves, plus knowledgeable local officials, to help in searching out the firms. The following are are the main conclusions.

First, firms in the industry were classified into 2 types :

1. General repair shops. These are small firms generally employing less than 10 workers. Their main business is repairing, components and produce complete machine on order although not more than 10 units per year.

2. Manufacturing firms. They employ more than 10 workers, but usually not more than 60. Their main business is the manufacture of farm machineries and they do not have to wait for orders before starting production. They also produce more than one kind of machinery.

This study concentrated on type-2 firms which represent the early stages of the development of an industry with potentially great importance to agriculture. The lists of the 26 firms are shown in **Table 3.**

**Table 3.** Distribution of firms surveyed in 9 provinces(1973)

| Province | Number of Firms |
| --- | --- |
| Ayudhaya | 3 |
| Chacheong-sao | 8 |
| Chonburi | 1 |
| Lopburi | 2 |
| Metropolis | 3 |
| Nakorn-Sawan | 3 |
| Patum-Thani | 1 |
| Ratburi | 1 |
| Saraburi | 4 |
| Total | 26 |

Second, most of the 26 firms are located in the major changwad towns (Ampur Muang) or in an ampur nearby. Only a few firms were owned by the indigenous Thai. Mostwere owned by Chinese-Thai families. The firms had usually been in business for 8 to 10 years.

Third, the products manufactured by type-2 firms are as follows : (rank from highest to lowest in terms of number produced). four-wheeled tractor (small) two-wheeled tractor (small) disc plow (for big tractor) mold board plow (for big tractor) corn sheller, sorghum thresher hay and grass mower (for big tractor) seed cleaner rice mill (small) other equipment for big tractor' such as dozer blade.

### Selection of Firms for Further Study

The result of the first round survey led to the decision to concentrate further on two products : the small two-wheeled and four-wheeled tractors. This decision was made because these products are potentially of great importance to the typical Thai rice farmer. The price of small tractors is whithin reach of most rice farmers, whereas the big tractors are more suited for custom work and ownership by large wealthy farmers.

Out of the 26 firms found in the survey, 6 were selected as representative firms for the purpose of this study. There were two large firms (50-55 workers), 2 medium firms (30-35 worker) and 2 small firms (10-15 workers). The classification and selection was based on the relative size of firms and their co-operation. The data collected were not relevant in some cases and hence further adjustments were made.

### Characteristics of Firms

It is interesting to note that among the 26 firms which were interviewed in 10 provinces in the Central plain, almost all of then sold tractors to Supanburi. On the other hand, the tractor producing firm in Supanburi was of no significance to the market sales in that area.

The farm tractor market in Chachoengsao is much larger. A special characteristic of the firms is that they produce only two-wheel tractors and low-lift irrigation pumps. All of the firms are of small size and their sales are directed mainly to the local farmers, although some also sell to other provinces. There is a tractor implement manufacturing firm which is also a dealer in large imported tractors.

### Market Structure

There is no monopoly market for tractors in Thailand. No single firm has reached a size large enough to achieve economies of scale. The comparative costs are similar among firms[4]. The machine tools used are different only in quantity, not in type. Only onė firm in Chonburi used a hydraulic pump which is more expensive and more efficient than the ordinary type. However, the production of this firm is focused on oil refinery mahinery rather than tractor. Some have special tools, such as the sprocket-wheeled cutter. The firm can supply their own sprocket wheels which are important parts of the farm tractor. During the slack months (May to August) of tractor sales, they can rely upon the production of sprocket wheels to keep their labor force busy.

Most farm tractor firms have been in existence for only 2 or 3 years. They started as automobile or bicycle mechanical repair shops. A tractor produced by this kind of shop will be similar in price to one produced by a real manufacturing firm. Some customers prefer the home workshop type as it is nearby, a breakdown in the machine can be easily and conveniently repaired by the local manufacturer.

Due to their recent establishment and financial constraint on the firms, the scale of production has become small (a few thousand two-wheel and about 500 units of four-wheel tractors per annum). Most of the partnership types are for tax reduction and exemption purposes rather than for capital expansion. The firm owners do everything from administration, machine designing, sale promotion to the manual labor. The survey found none of the firms had any branches except for the seperation of business between brothers to form a new business.

### Employment

From the study of 6 representative firms in 4 provinces, the number of workers employed ranged from 11 to 55 and daily wage-rate ranged from a maximum of 60 baht to a minimum of 5 baht (**Table 4**). The firms, except for firm 4, provided lodging for the workers. The working time was an average of 8 hours per day, 6 days a week. The wage was paid every two weeks.

**Table 4.** Daily wagerate paid by small tractor producing firms

| Firm | Number of employees | | | Wage-rate | |
|---|---|---|---|---|---|
| | Male | Female | Total | Max | Min |
| 1. | 55 | – | 55 | 60 | – |
| 2. | 54 | – | 54 | 50 | – |
| 3. | 35 | – | 35 | 50 | 15 |
| 4. | 30 | – | 30 | 60 | 15 |
| 5. | 12 | – | 12 | 40 | 20 |
| 6. | 11 | – | 11 | 50 | 5 |

Source : Survey(1973).

Usually the workers had been trained within the firm itself. The skilled workers who received higher wages were not graduates of any vocational school but started out as apprentices of the firms and gained their skills on the job. The firms prefered to train their own workers as they were more available and the relationship between the employee was well established. The workers were from local or nearby regions.

### Dealer Networks and Direct Sales

The market for farm tractors has made rapid progress in the last two years. It is interesting to note that in Ayudhaya the number of the two-wheel tractors produced has decreased whereas those of the four-wheel tractors increased. This is different from Chachoeng-sao, Samutprakarn and Metroplis Bangkok where production is concentrated on two-wheel tractor. Of the 6 firms studied, none of them experiencel any sale discrimination against the customers. They sold their products to dealers as well as to individual farmers. The customers were from everywhere. Some were local dealers or farmers, some were from other provinces, sometimes even from provinces where tractor manufacturing firms were situated. This phenonenon can be explained by the fact that some farmers are reluctant to buy a brand new tractor. They rely upon recomemndation of friends or relatives who had used a tractor before.

However, the sale pattern of each firm is slightly different due to sizes and locations. If a firm is not situated in the paddy producing region, most of its sale will be directed towards dealers rather than farmers, and more so with large firms .

### Credit and Cash Sales

Credit extension by the firm dealer levels depends on the individual rather than a set rule. It depends on the capital and willingness of the seller and the trustworthiness of the buyer. Generally, there is no legal sale contract between the firms and the dealers. i, e., the business tends to resemble the Chinese commercial types, the businessmen believe in each other and the transaction is carried out by words or by some note-sheet, not for legal evidence but rather for memorandum. The general practice would be for the dealer to pay the producer for the merchanlise after the next transaction is made, which means about 1 or 2 months credit. If the payment is due and the dealer cannot repay the debt, the situation will depend on personal agreement and past relationship. Businessmen will try their best not to get involved with the courts of law. In business, ethics are more important than law. However, bad debts are not unknown.

On the other hand, when credit is given to the farmers something has to be taken as collateral, usually their cultivated land, the price of the tractor or other farm machinery sold on credit is higher than the cash price. An example can be given in the case of the low-lift irrigation pump. I met a lady on the morning of my second day in Supanburi. She bought an irrigation pump which cost her 3,200 baht. She had to pay 2.5 per cent interest per month to the dealer until she made the total payment, which would be after harvest. Thus, if she paid off the loan, say, in 4 months, her total payment would be 3,200 baht principal plus 320 baht interest which would sum up to 3,520 baht. However, in the same afternoon, a gentleman came to buy exactly the same type and same brand of irrigation pump at the shop. He offered to pay cash and after the bargaining the water pump was sold for 2,800 baht.

### Advertising and Foreign Import Competition

Advertising practices of the firms studied is not at all aggressive. The tractor is often demonstrated to farmers at local fairs and field days. Leaflets are distributed by a few large firms. Radio advertisements are rare, and television advertising is unknown. Most of the firms rely on their reputation, identification and the tractor display in front of their shops.

Although there is no real farm tractor manufacturing firms in Supanburi, there are a few shops and quite a few tractor dealers. Both locally produced farm tractors and imported walking tractors (Kubota) are available. The domestic and imported tractors are not homogeneous in either price or quality. The imported one looks better and is superior in quality, but the price is almost double that of the domestic tractor. Hence, the domestic model is more popular. The high price of the imported two-wheel tractor is due to its model and quality alone : not because of the distortion in the price system. The tariff rate for the two-wheel tractor is only 3 per cent, to add the cost of insurance, freight, transportation and business tax, the price was only 10 per cent higher. One importer noted the significant replacement of imported ones by domestic tractors. Chachoeng-sao was once an important market for Kubota but for the past 5 years there has been no demand for it as there are now about 8 tractor manufacturing fims there.

The imported tractor, especially the big ones with higher power (more than 50 HP), is too expensive for the typical farmers. The imported small four-wheel tractor (21 HP) is about three times more expensive than the local small four-wheel tractor (10 HP), while the price of the imported two-wheel (7 HP) is almost double that of the local counterpart.

### Capital Shortage of Manufacturers and Dealers

The tractor industry in Thailand is just 5 years old. Though some firms have been engaged in the tractor business for more than 15 years, it was just an "on order" type. The producers developed from mechanical or automotive repair enterprises. At present, there are approximately 100 small scale manufacturing workshop mostly in the Central Plain region.[5] It is noticable that these manufacturing firms grew without any encouragement or promotion from the government. It is not surprising that some of them are deeply in debt even though their current tractor sales are high. This is because the trial-and-error experience in the early production period was expensive. However, the condition of capital soundness varies from firm to firm. Some firms can afford to extend credit to their customers while others could not but rather even have the customers pay in advance.

## Demand for Small Tractors from the Viewpoint of Farmers

### Why Small Tractors Sell

The price of agricultural products and the cost of farm machinery are important factors affecting development in agricultural mechanization.[6] For example : 1973 was a good crop year and the paddy price rose sharply, coupled with an irrigation facility which allows adequate water for double cropping, hence eucouraged farm mechanization, With the expectation of an even higher price of tractors and another good crop year, demand for tractor increased even more. Some of the farmers surveyed were buying a tractor for second-crop cultivation (which starts around February). Some were not buying for an intermediate purpose, but were buying it sooner than needed as they were afraid that the tractor price would increase further (between January-March 1974, the price of the two-wheel tractor increases by approximately 10 per cent).

The price of the domestic two-wheel and four-wheel tractor varied from 4,000 to 6,000 baht and 12,050 to 16,500 baht, respectively **(Table 5)**.

**Table 5.** Tractor price 6 representative firms(1973)

| Firm | Two-wheeled (baht) | Four-wheeled (baht) |
|---|---|---|
| 1. | 6,200 | – |
| 2. | 6,000 | 13,500 |
| 3. | 4,200 | 16,500 |
| 4. | 4,800 | 9,500 |
| 5. | 5,000 | – |
| 6. | 6,000 | 12,000 |

Source : Survey(1973).

The tractor seems to be popular even when double cropping is not a common practice.

It should be noted that both Supanburi and Chachoeng-sao are paddy areas and the use of tractors is wide-spread. The difference between these two provinces is the distance from the Metropolis where the opportunity for urban job exists for the labor released from farm work. Chachoeng-sao is much nearer to Bangkok and the employment of tractor is ubiquitous.

### How Individual Farmers Decide to Buy Small Tractor

The need to boost output, employment and income levels in agriculture was readily apparent. The solution would be the introduction of new farm technology. The "miracle-seed" leads to higher yield, more employment and higher income level. For this reason, other inputs have to be introduced at the same time. Whether or not the farmer can employ the new technology depends on his access to credit, the land tenure system, the avaliability of technical advisory services, market and distribution channels and the structure of costs and prices.[7]

Intensive cultivation is possible only if the land can be prepared in time. To prepare the land right after the first harvest by the drought power is almost impossible as the straw left over is too dry and hard. The cost of hired tractor service rose from 30 baht per rai in 1973 to 50 baht per rai in 1974. Besides the problem of a high service charge, the farmers also have trouble with the delays of the tractor contractor. Hence the farmers tend to buy their own tractor.[8]

The farmers who buy small tractors finance their purchasing by either selling their buffalos or making loans. Sometimes they pay a down payment and payback the rest after harvest, and undoubtedly the price they pay for the tractor is high. The farmers usually rely upon their friends or relatives for the loan. Marcus D. Ingle suggested that the Bank for Agriculture and Agricultural Cooperative (BAAC) credit program can play a direct role in resolving farmer financial problems.[9]

In Supanburi and Chachoeng-sao, the average land holding of the farmers interviewed was approximately 40 rai and 50 rai respectively, and the average nunber of tractor owned per farmer was 0.80 and 0.40, respectively. The figure of 0.80 may be misleading as most interviews were made at the tractor dealer shops (14 samples in Supanburi and 50 samples in Chachoeng-sao).

What is the relationspip between farm size and tractor ownership? In Supanburi, farmers with a farm size of 30 to 75 rai would own 1 tractor and those with more than 75 rai would own 2 tractors. In Chachoeng-sao, The figures are not clear, but they illustrate the tendency towards tractor ownership in large farm holdings.

In Supanburi, the farm size averaging 40.64 rai has 1 tractor, where in Chachoeng-sao the average one-tractor farm size is 86.85 rai. Jave Hamid,[10] using the Chancellor Formula for studying the tractor demand in Pakistan, after substituting the data concluded that the optimum tractor size was 10 HP which was applicable in the case of farm sizes of 14.50 acres (36.25 rai). A subsistence farm was 12.50 acre (31.25 rai) and the smaller farms tend to be consolidated towards this size.

**Cost-Benefit Comparision among Small Tractor, Animal and Contractor Service**

When farmers were asked why they sold their buffalos and bought a small tractor instead, the responses were :

- —A buffalo works fewer hours compared to a tractor.
- —A tractor works faster.
- —The land is too hard for animal tillage in the second cropping.
- —The hired tractor service fee is increasing and sometimes the contractor is late for appointment.
- —Buffalo thieves are common, and the buffalo is very expensive.
- —The tractor is a versatile machine.

At Chachoeng-sao, 44 per cent of the farm households used only mechanical power, 30 per cent used animal power and 26 per cent used both mechanical and animal power.

Taking the average farm size of 50 rai, the tillage costs (plowing and harrowing cost) and the percentage of farm income is shown as the following : self-owned tractor, 3.51 percent ; hired tractor service, 4.11 percent ; and animal power, 4.86 percent.

## Summary and Policy Implication

1. Distribution of sales. Manufacturing firms distributed their products to both dealers and farmers. The distance between the manufacturing firms the paddy areas somehow determined the proportion of buyers.
2. Price and credit allowance. The tractor price varied slightly among firms. There are "dealer price" and "farmer price". The discount is between 10 and 20 percent. In most cases, the dealers paid in advance while the farmers paid later.
3. Stock and storing. Only the big manufacturing firms can produced some whole tractor bodies for inventory. Some manufacture only parts of the tractor which are more time consuming and demand less space.
4. Promotional activities. The general practice of the firm is a tractor display. Most customers obtain tractor infomation from friends or relatives.
5. Capital shortage problem of manufacturers. If the tractors can be used as collateral, the firms would be able to overcome the capital shortage and increase the scale of production.
6. Capital shortage problem of farmer. Most tractor dealers were engaged in several products other than tractor. Their financial situation was sound. They served as a main financial source for the farmers in purchasing farm machinery.
7. Design problem. It is necessary for the firm to co-ordinate reseach with other institutions. Direct support in the form

of technical advice would be the most important. Tax reduction and subsidies are short-run measures, but sound technical knowledge will help the tractor business in the long-run.

8. Foreign import problem. Now that the price of imported tractor is high, opportunity exists for the local manufacturing firms to improve their product and compete with the importers.


## ACKNOWLEDGEMENT

This paper is the summary of my master thesis. The assistance of Professor Delane E. Welsch for the initial work is deeply appreciated. The research fund from the International Rice Research Institute is also appreciated. Special thanks are due to Professor Motosuke Kaihara who assisted in the summary of this work and many others whose names the author will always remember.


## REFERENCES


1. Royal Thai Government and Industrial Finance Cooperation of Thailand and United States Operations Mission to Thailand, "Thailand Farm Mechanization and Farm Machinery Market", A Co-ordinated Industry Study Project, 1969.
2. Department of Customs, "The Annual Statement of the Foreign Trade of Thailand", (1963–72).
3. Waranya Rewan. Case Study of An Engine Manufacturing Firm in Thailand (Thammasat University, Bangkok, June 1973).
4. Chirmsak Pinthong. Economics of Small Tractor Production in Thailand, Master of Economics Thesis. (Thammasat University, Faculty of Economics, 1974).
5. Samnao Ragtrakul and Chak Chakkaphak. Equipment Used in Thailand's Agriculture and New Developments in Equipment Designed for Rice Cultivation, (Workshop on Agro-industrial Development in the Lower Mekong Basin, 26 November–18 December 1973, Bangkok, Thailand).
6. Wang Jaw Kai. A Multiphase Strategy for Agricutural Mechanization, "Agricultural Mechanization in Asia". (Vol. IV No. 2, Autumn 1973, Farm Machinery Industrial Research Corporation).
7. Morsden, Keith. Technological Change in Agriculture, Employment and Over-all Development Strategy, "Mechanization and Employment in Agriculture". (International Labor Office, Geneva).
8. Chancellor, William J. Survey of Tractor Contractor Operation in Thailand and Malaysia. (Agricultural Engineering Department, University of California, Davis, California, U.S.A).
9. Ingle, Marcus D. Small Farmer Credit in Thailand. (AID Spring Review of Small Farmer Crediet Vol XII, February 1973, No. SR 112).
10. Hamid, Javed. Agricultural Mechanization : A Case for Fractional Technology. (Teaching Form A/D/D, Development processes and planning, No. 33, September 1973). ■■

# Japanese Small Tractor

by
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### Introduction

Two-wheel tractors have played a leading role for the farm mechanization in Japan and about 3 million units are now in use. Recently owing to a high degree of economic growth and shortage of rural labour four-wheel tractors have leen extensively introduced and 832 thousand units of them are in use. The percentage of four-wheel tractor use to the total fram households is only 17.2 and the riding tractors are fast taking the place of the walking type. The manufacture of four-wheel tractor in 1976 numbered 235.9 thousand units compared to only 23.9 thousand in 1967, an increase of about 10 times in 10 years. On the other hand, the production of two-wheel tractors decreased to 295.6 thousand units from 477.7 thousand units at the peak production time of 1967. Most of the tractors used in Japan are small ones. The number of tractors under 15 PS account for 47.8 percent ; 15-20 PS, 24.2 percent ; 20-30 PS, 20 percent ; and over 30 PS, 8 percent. The bigger tractors are almost imported and local production is limited to the under-83 PS size. This coodition is mainly due to the agricultural conditions in Japan : small and intensive farming, part-time farming and nature of rice cultivation. The total number of Japanese farm households is 4,953 thousand of which 87.6 percent are part-time farms whose owners depend on employment in industry and/or commerce for supplementary earning, the balance are full-time farmers. The total arable land in the country is estimated at 5,615 thousand hectares, of which 3,209 hectares are paddy fields and the rest are upland fields. The average size of paddy fields is about 10 ares for convenience of irrigation and drainage. Paddy fields are now being consolidated to 20-30 ares or more for improving the field efficiency of the riding type of farm machinery.

※Presented at the Spring National Conference organized by The Institution of Agricultural Engineers, held at the National College of Agricultural Engineering, Silsoe, Bedford, U.K., on 21 March 1978.

### Tractor Types and Characteristics

The tractors manufactured in Japan are mostry the 10-30 PS size. They may be classified as small farm tractor but not the so-called garden tractor with gasoline-fed engine and of lighter construction. The main characteristics of Japanese tractors may be indicated as follows : rotary tiller tractor, multiple speeds with creeping speed, multiple PTO shaft speeds, multiple cylinder diesel engine of higher speed and the four-wheel drive. They are very suitable for Japanese farming ; i. e., small and intensive farming, small field, soft and wet paddy field and higher precision work. They are usually the rotary tiller types of which the main implements are rotary tiller and not the traction type. Rotary tilling is more dominant than plowing in Japanese paddy fields as plowing leaves furrows and ridges and that secondary tillage e. g., harrowing and puddling require longer hours of labor. In addition, rotary tilling results in good soil pulverization and reguires harrowing only as puddling with rotary tiller alone simultaneously levels the paddy fields.

As shown in **Fig. 1**, rotary tilling is more efficient as it is active tillage and the soil reaction R acts with the up-lift force V and horizotal thrust H, a reverse of the plow, type which facilitates the tractor performance. On paddy fields the traction efficiency is lower with higher rolling resistance and slippage of wheels. Much of the engine power is directly transmitted to the rotary blades for tilling the soil. Hence, the active tillage of rotary tiller is more effective than the passive tillage of the plow type of Tractor.

Tractors need more durable engine and construction for

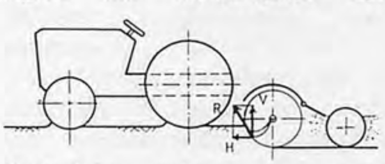



Fig.1 Forces actirgon tractor and rotary tiller (Four-wheel tractor)

13 hp tractor

17 hp tractor

22 hp tractor

rugged and continuous farm use. The diesel engines of multiple cylinders are dominant. Even the 13 PS small tractors have 3 cylinders and the 10 PS 2 cylinders. It is mainly due to the severe ergonomic demands in the domestic use, especially noise and vibration reductions are serious considerations of the tractor design. Multiple running speeds and PTO shaft sppeds are suitable for the rotary-tilling operation and other activities on the paddy fields and the upland fields.

Another characteristic of the Japanese tractor is the four-wheel drive feature. Hydraulic position control is also common among the small tractors. which is very suitable for rotary tilling. The draft control is featured only among the bigger tractors over 30 PS. Recently the electronic position control or power control mechanism for rotary tiller and hydro-static drive or power shift transmission have been introduced in the market.

23 hp tractor

. 30 hp tractor

## Design and Technical Features

In 1977 about 157 models of locally manufactured tractors with engines ranging from 10 PS to 83 PS were available in the market. Their design and technical features are adapted to Japanese conditions.

### The Tractor Weight

The tractor weight and its distribution on the front and rear axles are important factors for the maneuverabilhty of the tractor. The weight per horse power of the small japanese tractors has lower values than those of European tractors as shown in **Fig. 2.** The domestic tractors have about 30-55 kgf per horse power, and have the general tendency to decrease their values with an increase of the engine horse power. The main reason for tractors having lower weight per horse power is the need to fit them for the extensive usage of the rotary tiller, i. e. the basic design of the rotary tiller tractor. It needs more power to PTO shaft and less tractive force and power. The lower value of the weight per horse power is achieved by using the high speed diesel engine and lighter construction, and it improves the mobility of the traetor on soft and wet field. Al-

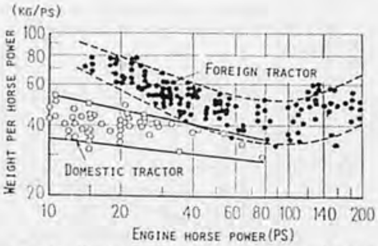



**Fig.2** Weight per horsepower of tractors

most all Japanese tractors have two models of the two-wheel drive and four-wheel drive types. The weights of the four-wheel drive tractors are heavier than the rear-wheel drive ones by 40 to 100 kgf. The weight distributions on the front and rear axles for the rear-wheel drive tractors are about 45 percent front and 55 percent at the rear. For the bigger tractors the front weight centages decrease to 40-42 percent. If the front axle load is light, there is a danger of rising up the front wheel. If it is heavy, on the contrary, steering on soft and wet field is difficult. These values seem a little higher than the conventional tractor, but with the mounting of the rotary tiller on the tractor these values becmne about 23-28 percent. The weight of the four-wheel drive tractors is almost equally distributed on the front and rear axles.

### Engine

Almost all the Japanese tractors even with low horse power are fitted with diesel engine with multiple cylinders, Only a few are fitted with gasoline engine. In recent years some tractors with only one cylinder horizontal engines were manufactured but most of them have since disappeared from the market. The cylinder diesel engine ; 25-35 PS are normally fitted with two cylinder diesel engine ; 25-35 PS three cylinders and over 35 PS four cylinders. Recent trends shows that even the 13 PS class tractor has three cylinder diesel engine. In spite of the popularlty of multiple cylinder engines for small horse porse power tractors

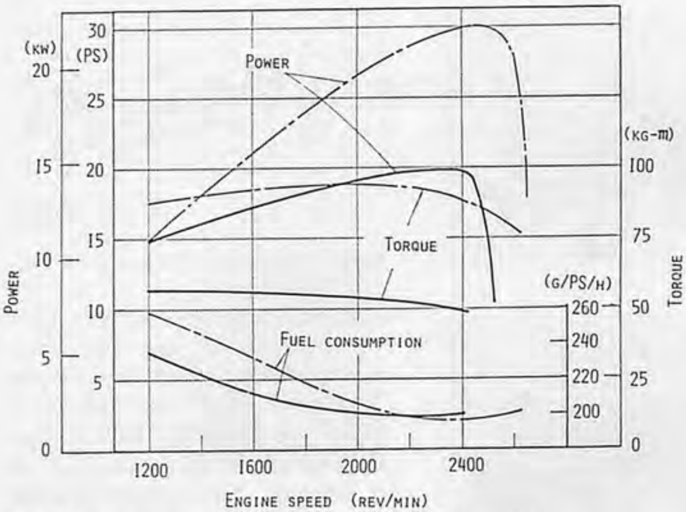



Fig.3 Characteristic performance curves of tractor engines

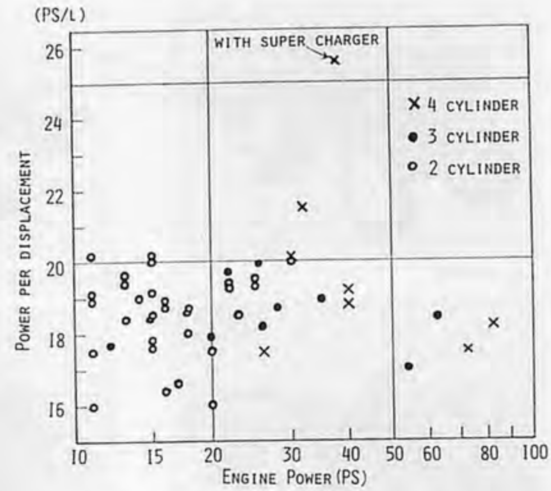



Fig.4 Power per displacement

resulting in smaller cylinder diameter and losing the advantage of elastic torque characterisitics of diesel engine and higher cost, the tendency is to aim at adapting them to the demands of lower noise and vibration.

The typical characterisitic performance curves of diesel engines are shown in **Fig. 3**. The torque curve of smaller engines is comparatively flat to the wide engine speed, and this is suitable for heavy rotary tilling work. This means that the smaller engine has less power reservation for heavy work load without being sensitive to speed change. The bigger tractors which are used for tractive rugged, heavy work have torque curves that increase by 20-25 percent with the drop of speed from the maximum horse power.

The speed of engines in Japanese tractors is higher than those of the Europian and American tractors. This means lighter weight of Japanese engines and higher power output per displacement **(Fig. 4)** with a rated speed of about 2200-2800 RPM. The minimum specific fuel consumption is about 200 g/PS/h at the speed ranges of the maximum torque. A small turbo super charger of 1500 RPM at maximum has been applied recently to the 30 PS class of 1487 cm³ displacement, which attains 38 PS output with the same engine. The super charger increases the horse power output per displacment to 25.6 PS/1 with improved thermal efficiency as shown in Fig. 4. Another advantage of the turbo super charger feature is that even the operator who is licensed to drive small cars can drive the tractor of which engine displacement is under 1500 cm³ without violating vehicular regulations in Japan.

## Travelling Devices

The majority of the tractors used in Japan have six forward speeds from 0.85 to 14.6 KPH, and two reverse speeds. The maximum speeds of the smaller tractors are a little lower to 10 to 12 KPH. New tractors have higher speeds up to 16-24 KPH with creeping speeds. The minimum creeping speeds are about 0.1-0.2 KPH. Normal tilling speed is 1-2.5 KPH, so that six speeds are enough for ordinary tilling work. But lower travelling speeds or creeping speeds are used for fine tilling, deeper tilling, transplanting, etc. These multiple speeds of small tractors enable them to adapt the rotary tilling work for various soil conditions. Many gear ratios are necessary by using the PTO driven equipments which must run at fixed speeds and hence do not require travelling speed change by altering the engine speed. The highest speeds of small tractors whose engine displacement are less than 1500 cm³ are limited to 15 KPH by Japanese legal restrictions of road traffic.

Some tractors have synchromesh hydrostatic transmission that enables speed shifting even under loaded conditions without stopping. They are also very useful for loader operation which repeats forward and reverse motions. However the efficiency of the hydrostatic transmissin is lower than the gear type. Some tractors have power shift transmissins of which the gears are shifted by hydraulic power **(Fig. 5)**. They have better efficiency than the hydrostatic transmissin but are not synchromeshed. Continued effort is being devoted to developing the automatic control of travel speed with sensing devicas for rotary tilling load or engine output.

For tractor travel on soft soil a differential lock is essential, including many subsidiary devices

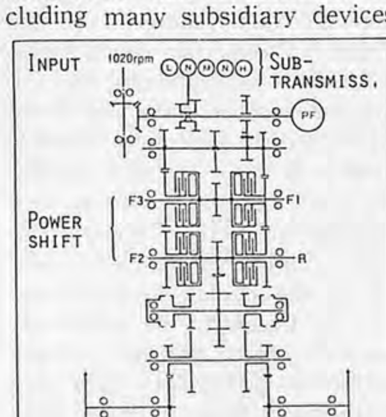



Fig.5 Power shift transmission

such as girdles, strakes, cage wheel, half track and special pneumatic tyres so-called high lugtyres. At the present time, most country roads in Japan are paved so that high lug tyres have become popular.

The four-wheel drive feature of tractors with smaller front wheels is another effective method of travel on soft soil. It has more tractive force than the rear wheel drive and about 30-40 percent of tractive force increases on the same condition. It is also convenient for the tractor to run over paddy field ditch and is suited for hillside work. The wheel bases of the smallest tractors of 10 PS class are about 1100 mm. ; tyre sizes of the front wheel are 4.00-10 2 pr ; 4.00-12 2 pr for the four-wheel drive ; 7-14 2 pr. for rear wheel.

### Power Take-off Shaft

Most of the European and American tractors have only one or two PTO shaft speeds of 540 to 1000 RPM but domestic tractors have usally three or four speeds. Tractors over the 15 PS class have a standard speed of 540 RPM but smaller tractors have speed ranges suitable for rotary tillers. Some examples of PTO shaft speeds are shown in **Table. 1.**

Rotary tilling operations require more rotary speeds according to soil conditions and the degree of soil pulverization. If the change gears are on the tractor, not on the rotary tiller, the gear shift is easily operated from the driver seat not to mention the lighter weight of rotary tiller. Small tractors can be used with the combination of many PTO shaft speeds and many travelling speeds for various farm conditions.

Table 1. PTO shaft speeds

| Engine power ps. | | 11 | 11 | 22 | 30 |
|---|---|---|---|---|---|
| PTO-shaft speed | 1st. | 462 | 540 | 547 | 542 |
| | 2nd. | 765 | 847 | 709 | 685 |
| | 3ed. | 1280 | 1320 | 929 | 1005 |
| | 4th. | — | — | 1230 | 1268 |

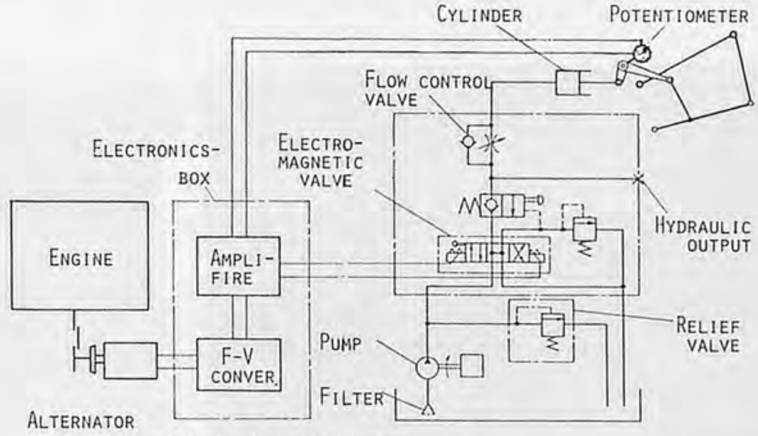


Fig.6 Electronic hydraulic control system

### Hitching and Hydraulic System

The tractors over the 15 PS class have usually three-point linkage hitch. The smaller tractors ranging from 10 to 15 PS have special two-point linkage hitch or direct fitting devices for the rotary tiller. The bigger tractors have the three-point linkage hitch of category 1. The smaller tractors have that of category 0. The category 0 in JIS (Japanese Industrial Standard) is almost similar to that of category IN in ISO plan, fut with wider hitch point spread of 565 ± 1.5 mm (400 ± 1.5 mm in ISO), longer mast height 410 mm (360 mm) and amaller lift range of 300 mm (420 mm). These differences are mainly due to the fact that the Japanese hitch is intended for the rotary tiller whereas the Europian hitch is dusigned for the plow.

The capacities of hydraulic pumps used in the 10 PS class are about 7 1/min. 'and gradually increase' with higher power to 30 1/min. in the 30 PS class. The relief pressures used are about 140-155 kgf/cm$^2$ (13.7-15.2 Mpa.) Small tractors have no position fontrol system and the tilling depth is controlled by the gauge wheels attached behind the rotary tiller. The tractors over 15 PS class usually have the position control which gives flat cultivation and more tilling force by combining the weight of the tractor and the rotary tiller when the control valve is in neutral position. The bigger tractors over 30 PS have also the draft control system.

Recently the electronic hydraulic position control system or the combination of position and power control system of the rotary tiller was introduced in the market. One position control system has a sensing device attached to the rotary tiller cover touching the ground. Another position control system has a sensing device of potentionmeter attached to the lift arm shaft and the rotary tilling is sensed by the drop of engine speed using alternator's electric pulse and converted to electric voltage with electronic circuit **(Fig. 6)**. With electric signal the magnetic valve is activated and lifts the rotary tiller by gradual steps. This system does auiay with the use or the gauge wheel and is easy to adapt to soil conditions and to do mixing control.

### Farm Implements

The rotary tiller is of course the main implement for the small tractors mentioned above. There are many choices of other implements such as plow, harrow, vibrating mole drainer, seeder, broadcster, pest control machine, hay making machine and front loader.

The rotary tillers for small tractors have relatively shallow tillage depth of about 10 to 15 cm. The tilling widths are usually wider than the outer width of the

Tilling by rotary tiller

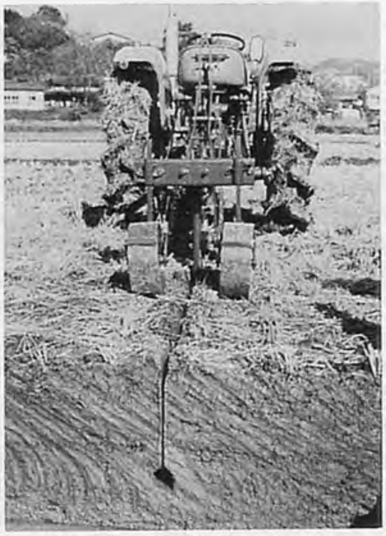
Puddling on submerged paddy field

Deep ploughing by bottom plough

tyres to achieve higher capacity and better finishing of tillage. The minimum width of the rotary tiller for the 10 PS class tractor is about 900 mm.

The design feature of the rotary tiller for the small tractor is to reduce power consumption in spite of its width, hence the number of tilling blades is reduced, tilling speed is lowered and lower resistant blades are used. Ordinary tilling higher torque and fluctuation of the rotary tilling are the limiting factors of the rotary design.

The deeper tilling rotary tiller is so designed that its shaft sinks down under the ground level with the use of very slow travel speed and special blade arrangement. The front loader is also attached to the small tractors. It is very useful for hay handling in small farms and snow moving. The rotary tiller does not have to be detached during these operations. It also features a quick attaching device of the front loader (docking loader).



Tractor-mounted vibrating mole drainer

Tractor-mounted rice transplanter (6-rows), at work

Mulching by two-row mulcher

## Some Technical Problems

The tractors are often used for puddling on paddy field, hence water-proofing at the brake system, front axle, rear axle, PTO shaft and rotary tiller shaft is an important design factor for rice cultivation. The brakes of domestic tractors are sealed and suited on the shafts in front of the rear axle. Rubber seals and O-rings are fitted at many places of the shaft systems.

Safety and comfort of the driver is a big problem for the small tractor. The safety frame for small tractors which have lighter weight presents hazards and problems for the higher gravity center and the danger of overturn. Although there are no legal restrictions in japan to attach the safety frame or cabs, this problem needs to be solved soon. Another ergonomic demand of lower noise and vibration reduction as well as lower emmission of CO and NOx are new problems facing the tractor designers and technologists. ■■

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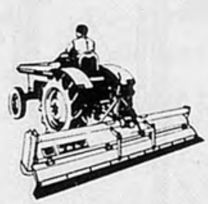

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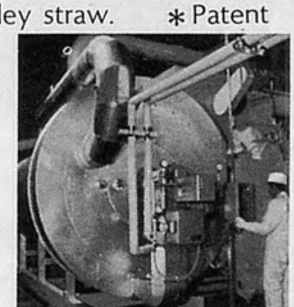

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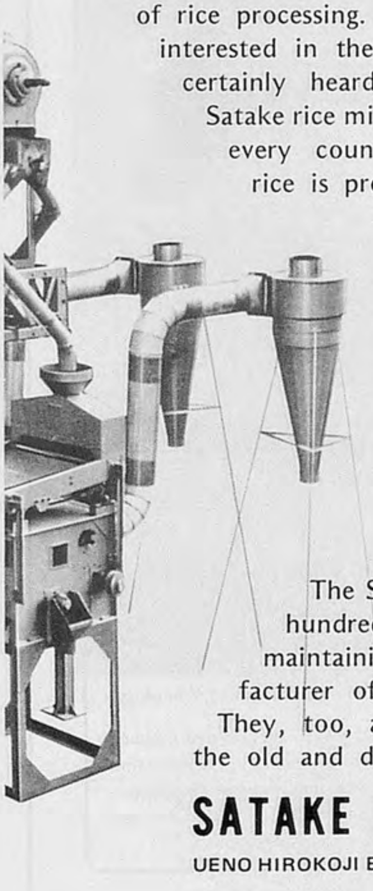

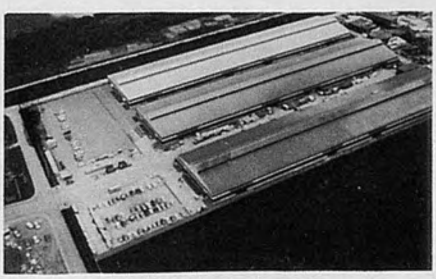
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# Performance Studies of Country Ploughs in Bangladesh

by
Md. Daulat Hussain
Assistant Professor

Md. Rafiqul Isiam Sarker
Associate Professor

Department of Farm Power & Machinery Bangladesh Agricultural University
Mymensingh, Bangladesh

## Introduction

The country plough is one of the oldest of all agricultural implements throughout the world and it is still the most important tillage equipment in Bangladesh. The use of machine power in agriculture is very negligible. The per acre crop production is 0.421 tons per acre (Choudhury, 1972). Yield studies have indicated that under · certain conditions with some crops there is apparent advantage in ploughing (Kepner, 1972). The country plough is still by far the most used implement in primary tillage in seedbed preparation. High yield crop production is based on the stirring of the soil with some type of implement, usually a plough, to provide well pulverized seedbed (Barris, 1955).

Bangladesh has a wider range and greater complexity of soils. To-date, more than 200 soil series have been established, of which about 80 (Brammer, 1975) can be considered important soils. The whole soil series can be grouped into four main divisions : Chittagong hill tracts and related areas ; Pleistocene terraces ; Himalyan piedmont alluvial plain ; and Fresh deltaic flood plain.

Soils are mainly silt, silty clay loam, clay loam and sandy loam. Depending on the different types of soil structure and texture, the Bangladesh farmer uses different shapes, sizes of tillage implement for tillage opreations. The shape, size and weight of country ploughs vary with different localities of Bangladesh.

Heretofore, no comprehensive information was available on the performance of country ploughs. For the proper and suitable design, some basic information is needed on the existing ploughs which are currently being used in tillage purposes. With a view to collecting some information on exsting country plouges, some experimental investigations were carried out at the Bangladesh Agricultural University farm which included the measurement of drawbar horsepower, specific draft, width of cut, depth of ploughing, etc.

## Capacity of Draft Animals

Many facfors affect the capacity of a draft animal, including the kind and size of animal, condition, training, footing, method of hitching and speed of travel. The normal draft capacity of an animal is approximately on tenth of its weight (Hopfen, 1960).

**Table 1** gives the examples of the capacity of various draft animals,

Bullock or cow power is not uniform during the course of its operation in the field. At the begining the output of power is high but decreases as the duration of working time increases **(Fig.30)**. That is why the tilling work is not up to the required mark. The best tillage provides good yield of crop. It is experimentally found that with proper tillage and land preparation by improved agricultural imple-

**Table 1.** Capacity of draft animals.

| Animal | Average Weight(Kg.) | Approximate Draft(Kg.) | Average Speed(m/sec) | Hp Equivalent |
|---|---|---|---|---|
| Buffalo or Carabaos | 452 | 55[1] | 1.04 | 0.75 |
| Cows | 400−600 | 50−60 | 0.70 | 0.45 |
| Bullocks | 500−900 | 60−80 | 0.60−0.85 | 0.75 |
| Bullocls | 980 | 123[2] | N.A. | N.A. |
| Bullocks | 350 | 55−70[3] | N.A. | N.A. |

Source : S, B. A. Equipment for rice production, FAO. Rome, 1966. pp. 33.
1. The maxmum pull recorded in the Philippines during this test was 410kg.
2. Maximum, India.
3. A well fed adult, Senegal.
N.A. = Not available.

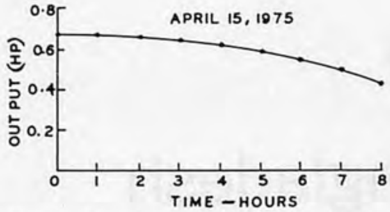


Fig.30 Capacity of one pair of bullocks during field operation

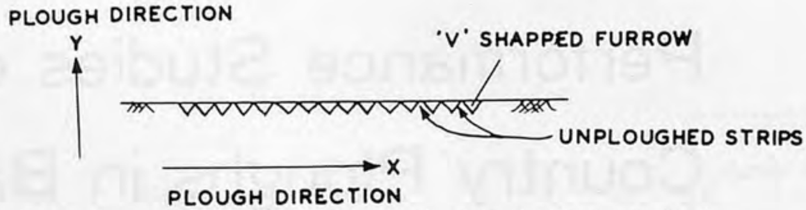


Fig.31 Cross sectional view of land preparation method with country plough

ments, an increased production of crop up to 20 to 25 percent (Haque, 1967), may be obtained.

## Country Plough of Bangladesh

Most of the ploughs used in Bangladesh are made by the village blacksmiths. There are many shapes and sizes of which some are big, some medium and some small. Generally, big and medium ploughs are used for dry field work and small are used for wet field cultivation. A typical country plough is shown in **Fig.29** The specifications of this plough are shown in **Table 2.**

**Table 2.** Specifications of country ploughs

| Item (shown in Fig. 29) | Value * |
|---|---|
| x | 2′ −8″ −3′ −0″ |
| y | 1′ −10″ −2′ −6″ |
| z | 1′ −2″ −1′ −6″ |
| p | 3′ −4′ |
| q | 5′ −6′ |
| s | 2′ −4″ −4′ −0″ |
| θ | 60° −65° |
| β | 80° −100° |
| φ | 13° −15° |
| φ′ | 30° −35° |
| Weight | 10 −30 lbs. |
| I | 6″ −10″ |

* The values are obtained from a survey conducted by the department of Farm Power & Machinery, Bangladesh Agricultural University, Mymensingh in 1974.

## Characteristics of Plough

i) The plough cannot turn the soil over as it has no moldboard.
ii) The furrows cut by the plough are 'V' shapped and as a result unploughed strips are left between furrows. The land has, therefore, to be ploughed in different directions in order to break up the unploughed strips (**Fig.31**).
iii) The depth of ploughing is only 2–3 inches and width of cut is 6".
iv) It takes more time and labour than that of moldboard ploughing.
v) During tilling operation, the plough proceeds in series of jumps, doing very poor work and making it harder for bullock to pull.
vi) The line of draft does not pass through the center of the resistance of the plough and therefore plough does not ride steadily at a uniform depth.
vii) The ploughs are light enabling ordinary bullock or cow to pull them easily.
viii) Simple knowledge is required for its manufacture and is very cheap in comparison with imported moldboard plouges.

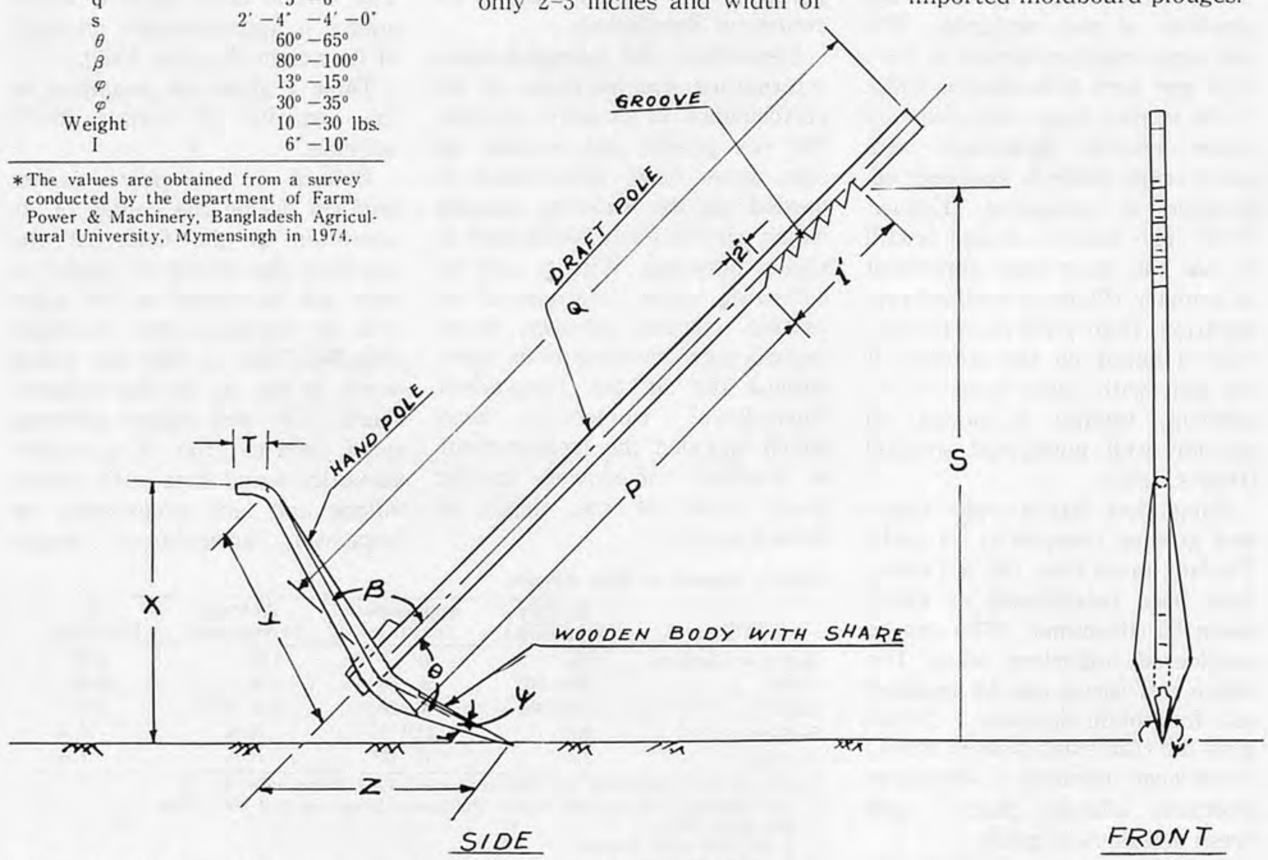


Fig.29 Typical example of a country plough Specifications are shown in Table 2.

### Depth Adjustment

The control mechanism of depth in a country plough is maintained by 'Heel toe' principle. If the implement runs deeper than normal working condition, it will pitch backward slightly rotating about the hitch point and an additional soil support force will be induced in the plough. This restores it to its equilibrium depth. Something happens when the implement runs shallow : it will pitch forward hence downward soil force is induced which restores the implement to its normal working depth.

In real practice, depth of ploughing is adjusted by changing the length P (**Fig. 29**) with the yoke. The range of adjustment is limited.

### Draft on Plough

The draft require for country plough is affected by many factors such as the size and shape of the bottom, the overall hitching arrangement, the depth and width of furrow, soil types and its characteristics. The main factor is the speed of the plough in the field. The draft may range from 5 to 12 Psi in case of moldboard plough (Agric. Engg. Year Book, 1954) but with country plough it is 10 to 37.0 Psi.

The draft of the country plough can be determined by a dynamometer which indicates the pull or draft of the plough over a measured distance. Then, knowing the rate of travel, the horsepower as well the specific draft can be determined.

Drawbar Horsepower (DBHP)

$$= \frac{\text{Pull by the cows or oxen} \times \text{distance travelled in feet per minute}}{33{,}000} \quad \cdots\cdots (1)$$

Specific draft

$$= \frac{\text{Pulling force at a certain time}}{\text{Cross-sectional area of the furrow slice at that time}} \quad \cdots\cdots (2)$$

### Effective Field Capacity of Country Plough

The effective field capacity of the country plough may be expressed by the following relation (Mckibben, 1930) :

$$C_P = \frac{5280 \times S \times W \times Ef}{43{,}560 \times 100}$$

$$= \frac{SWEf}{825} \quad \cdots\cdots (3)$$

Where $C_p$ = Effective field capacity of plough in acres per hour.

S = Plough speed in miles per hour.

W = Rated width of cut of implement in feet.

$E^-$ = Field efficiency in percent.

Field efficiency is the ratio of effective field capacity to theoretical field capacity, expressed as percent. The effective field capacity is the actual average rate of coverage by the plough.

### Results and Discussions

Ploughs were colleted from 19 districts of Bangladesh. Twenty-eight ploughs were tested of which 7 were from Mymensingh, 3 from Comilla, 2 from Dacca and one plough each from the rest of the districts. The general features of the ploughs are shown in **Fig. 1** to 28.

The weight of the individual ploughs were measured in the Agricultural Machinery Laboratory. A 1.5 acre seice of land was selected for test performance of the ploughs. A spring loaded dynamometer was designed and constructed to measure the pulling force required for the ploughs. Performance data were recorded in the field in three replications. Time per bout, depth of cut and width of cut were recorded. The time per bout and total time for field operation were recorded with the help of a stopwatch. The drawbar horsepower required for each ploughs were calculated from equation (1) and the specific draft also estimated from equation (2). The field capacity of the ploughs were calculated from equation (3).

There were 28 × 3 plots. Area of each plots was 600 ft$^2$ and the soil was homogeneous. A local variety of paddy 'Dhariol' was cultivated in each plot. No fertilizer was used to see the tilling effect of the individual ploughs. The minimum and maximum tilling area were 0.042 and 0.077 acres per hour and corresponding drawbar horse-powerwere 0.27 and 0.40 for the ploughs $P_{22}$(**Fig. 22**) and $P_{10}$ (**Fig. 10**), respectively. The minimum and maximum specific Draft recorded were 10 Psi and 31.0 Psi for the ploughs $P_6$(**Fig. 6**) and $P_{22}$. The test results are shown in **Table 3**.

Fig.1 Plough No.1

Fig.2 Plough No.2

Fig.3 Plough No.3

Fig.4 Plough No.4

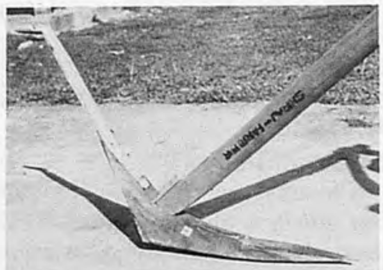

Fig.7 Plough No.7

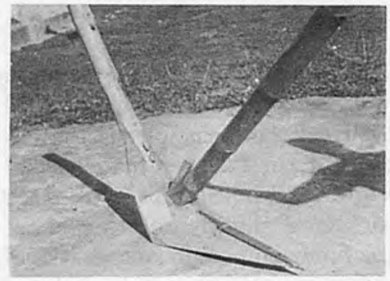

Fig.10 Plough No.10

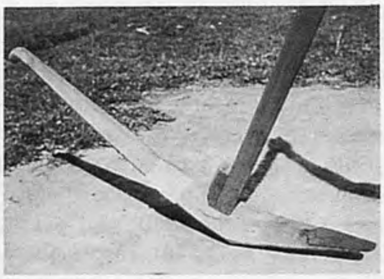

Fig.5 Plough No.5

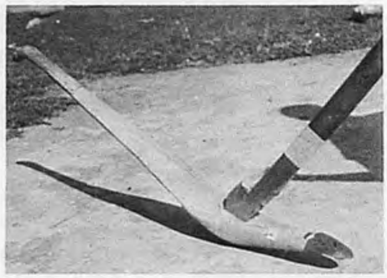

Fig.8 Plough No.8

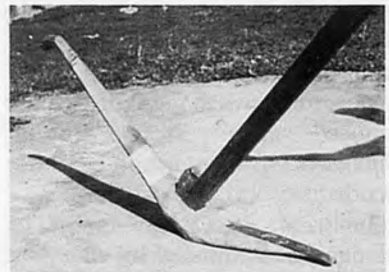

Fig.11 Plough No.11

Fig.6 Plough No.6

Fig.9 Plough No.9

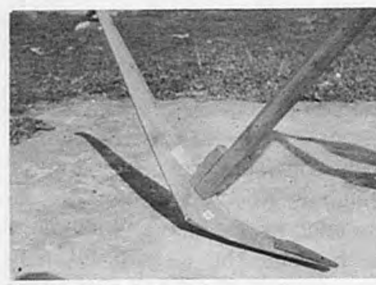

Fig.12 Plough No.12

**Table 3.** Performance of country ploughs

| Plough No. | Plough Weight (lbs) | Average Width of Cut (inch) | Average Depth of Cut (inch) | Tilling Area (acres/hr.) | Drawbar horse-power (Hp) | Pulling Force (in lbs) | Average Speed (ft sec.) | Specific Draft (Psi) | Average Yield /6QO ft² (lbs) |
|---|---|---|---|---|---|---|---|---|---|
| $P_1$ | 15 | 4 | 2.25 | 0.0635 | 0.37 | 90 | 2.31 | 20. | 25.1 |
| $P_2$ | 19 | 4.25 | 3 | 0.059 | 0.38 | 100 | 2.14 | 15.7 | 33.2 |
| $P_3$ | 12 | 2.75 | 2.25 | 0.044 | 0.33 | 80 | 2.4 | 25.8 | 31.5 |
| $P_4$ | 25 | 4.75 | 4 | 0.065 | 0.36 | 100 | 2.0 | 10.5 | 27.2 |
| $P_5$ | 10 | 3.8 | 2 | 0.058 | 0.33 | 75 | 2.22 | 19.7 | 26.7 |
| $P_6$ | 16 | 4.0 | 3.5 | 0.063 | 0.29 | 70 | 2.31 | 10.0 | 36.0 |
| $P_7$ | 20 | 3.5 | 3 | 0.053 | 0.36 | 90 | 2.22 | 17.1 | 25.0 |
| $P_8$ | 9 | 3.0 | 2.5 | 0.052 | 0.27 | 60 | 2.5 | 16.0 | 20.5 |
| $P_9$ | 11 | 3.5 | 3 | 0.054 | 0.33 | 80 | 2.31 | 15.20 | 24.0 |
| $P_{10}$ | 19 | 5 | 2 | 0.077 | 0.40 | 100 | 2.22 | 20.0 | 26.6 |
| $P_{11}$ | 15 | 4 | 2 | 0.060 | 0.38 | 100 | 2.14 | 25.0 | 25.4 |
| $P_{12}$ | 13 | 4 | 2 | 0.060 | 0.42 | 110 | 2.14 | 27.5 | 26.8 |
| $P_{13}$ | 14 | 4 | 3 | 0.058 | 0.41 | 109 | 2.10 | 12.1 | 24.8 |
| $P_{14}$ | 15 | 4.1 | 3 | 0.059 | 0.43 | 115 | 2.07 | 18.7 | 27.9 |
| $P_{15}$ | 18 | 4 | 2 | 0.059 | 0.38 | 100 | 2.14 | 25.0 | 20.1 |
| $P_{16}$ | 17 | 5 | 2.75 | 0.083 | 0.34 | 80 | 2.40 | 11.6 | 21.8 |
| $P_{17}$ | 14 | 4.5 | 3 | 0.072 | 0.31 | 55 | 2.31 | 11.1 | 21.0 |
| $P_{18}$ | 13 | 4 | 2.5 | 0.064 | 0.33 | 00 | 2.31 | 16.0 | 23.5 |
| $P_{19}$ | 13 | 4 | 2 | 0.059 | 0.31 | 00 | 2.14 | 20.0 | 19.2 |
| $P_{20}$ | 9 | 3.5 | 2 | 0.054 | 0.37 | 90 | 2.31 | 25.7 | 21.8 |
| $P_{21}$ | 12 | 4 | 2.5 | 0.061 | 0.36 | 90 | 2.22 | 18.0 | 21.0 |
| $P_{22}$ | 12 | 3 | 1.5 | 0.042 | 0.27 | 70 | 2.0 | 31.0 | 30.2 |
| $P_{23}$ | 12 | 4 | 3.0 | 0.061 | 0.32 | 80 | 2.20 | 13.3 | 25.0 |
| $P_{24}$ | 10 | 3.7 | 2.7 | 0.061 | 0.36 | 85 | 2.36 | 17.0 | 24.8 |
| $P_{25}$ | 10 | 4 | 2.0 | 0.061 | 0.32 | 00 | 2.22 | 20.0 | 25.0 |
| $P_{26}$ | 25 | 5 | 3.0 | 0.069 | 0.36 | 100 | 2.00 | 13.3 | 22.8 |
| $P_{27}$ | 25 | 5 | 3.0 | 0.069 | 0.32 | 100 | 2.00 | 13.3 | 22.9 |
| $P_{28}$ | 27 | 6 | 3.0 | 0.073 | 0.38 | 120 | 1.76 | 13.3 | 23.8 |

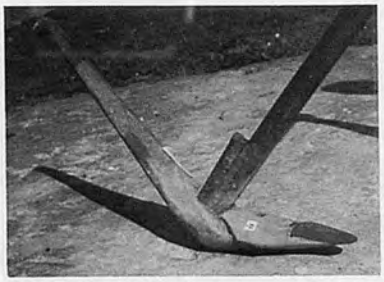

Fig.13 Plough No.13

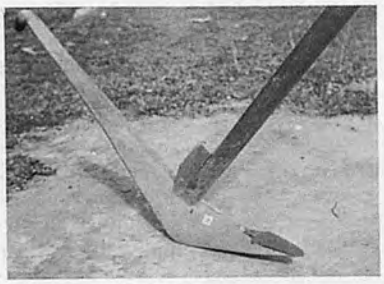

Fig.14 Plough No.14

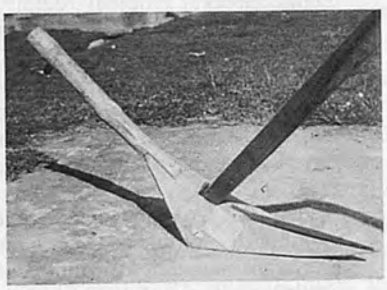

Fig.15 Plough No.15

Fig.16 Plough No.16

Fig.17 Plough No.17

Fig.18 Plough No.18

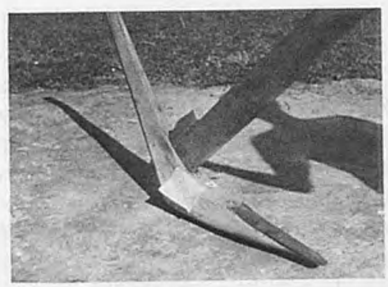

Fig.19 Plough No.19

Fig.20 Plough No.20

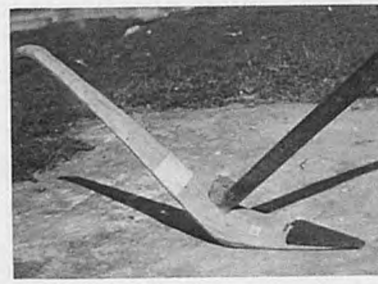

Fig.21 Plough No.21

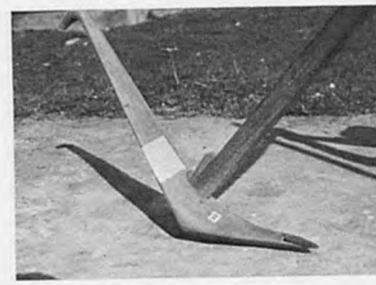

Fig.22 Plough No.22

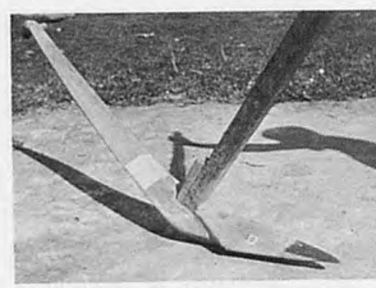

Fig.23 Plough No.23

Fig.24 Plough No.24

Table 4. Captions in figure

| Figure No. | Plough No. | Place of Collection | Figure No. | Plough No. | Place of Collection |
|---|---|---|---|---|---|
| 1 | $P_1$ | Brahman Baria | 15 | $P_{15}$ | Rongpur |
| 2 | $P_2$ | Potuakhali | 16 | $P_{16}$ | Khulna |
| 3 | $P_3$ | Netrakona | 17 | $P_{17}$ | Pubna |
| 4 | $P_4$ | Dinajpur | 18 | $P_{18}$ | Narayangonj |
| 5 | $P_5$ | Daudkandi | 19 | $P_{19}$ | Joydevpur |
| 6 | $P_6$ | Tangail | 20 | $P_{20}$ | Tarakanda |
| 7 | $P_7$ | Faridpur | 21 | $P_{21}$ | Fordabad |
| 8 | $P_8$ | Sylhet | 22 | $P_{22}$ | Fulpur |
| 9 | $P_9$ | Chittagong Hill Tracts | 23 | $P_{23}$ | Trishal |
| 10 | $P_{10}$ | Bogra | 24 | $P_{24}$ | Shambhuganj |
| 11 | $P_{11}$ | Chittagong | 25 | $P_{25}$ | Barishal |
| 12 | $P_{12}$ | Muktagacha | 26 | $P_{26}$ | Jessnre |
| 13 | $P_{13}$ | Fulbaria | 27 | $P_{27}$ | Kustia |
| 14 | $P_{14}$ | Haloaghat | 28 | $P_{28}$ | Rajshahi |


Fig.25 Plough No.25

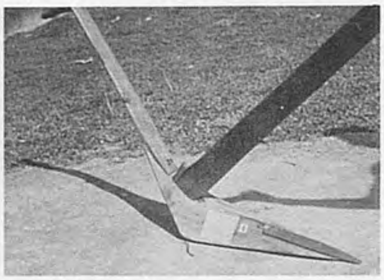
Fig.26 Plough No.26

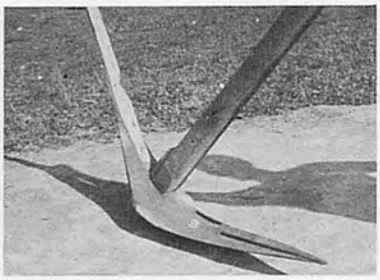
Fig.27 Plough No.27

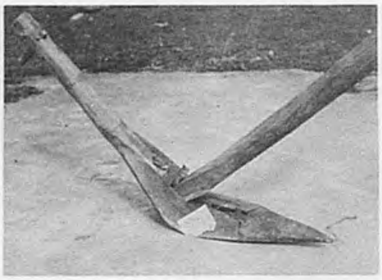
Fig.28 Plough No.28

## Conclusion

Without changing the over all shape of the plow and incorporating only the missing parts such as moldboard and landside, the presently used plough can be used more efficiently. This incurs only a small amount of additional money and will make it easier to operate. To make life of the plough longer, the share point should be of treated cast iron. Sharepoint is the only part of the plough which is subject to maximum wear and tear. Village blacksmiths after proper training and guidance will be able to make all these parts without difficulty.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. ASEA Data ; crop machine use ; I. Draft and power requirements of Crop machines, Agric. Engg. Yearbook, 1954, pp.69.
2. Brammer, H ; The soil of Bangladesh in relation to agricultural development. Paper pre, sented at a symposium on soil problems of Bangladesh. Organised by the soil science society of Bangladesh in Dacca, July 1975. (Unpublished).
3. Choudhury, M. S. U. Shortage of food grain and its solution. Published in Bangladesh Observer, April 16, 1972.
4. Harris Pearson Smith, A. E. Farm machinery and equipment, Fourth Edition, Mcgraw-Hill book company, INC. 1955. PP.90.
5. Hopfen, H. J. Farm implements for arid tropical regions. FAO. Agricultural Development Paper No. 67, 1960, PP. 158.
6. Kepner, R. A., Roy Bainer, E. L. Barger, Principles of farm machinery, Second Edition, The Avi Publishing Company, Inc. 1972.
7. Hoque, M. An improved light moldboard plough for East Pakistan, Souvenir, Agricultural Engineers Annual Convention, 1967.
8. Mckibben, E. G. Some fundamantal factors determing the effective capacity of field machines. Agric. Engg., 11 : 55-57, Feb., 1930.

# Design and Development of a Paddy Winnower

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## Introduction

A power-operated paddy winnower for the quick separation/cleaning of grains from the straw which has been threshed by any means is described. Essential features for its development include an air blower, air tunnel, screen, air regulating gate, a prime-mover (an electric motor or an engine) and structural work.

With the increasing speed of the green revolution in this country and acceptance of scientific and technical aspects of improved farming, the number of agricultural machines to reduce drudgery and to have timeliness of opreration is increasing on the farms. Winnowing of paddy is one amongst such farming operations where the farmer is more concerned in converting manual winnowing into mechanized winnowing.

In the absence of a suitable winnowing machine farmers have been doing the laborious job of paddy winnowing by traditional methods which means waiting for the high velocity and winnowing the paddy threshed by conventional method across the wind. This requires very heavy investment on labour cost which increases the cost of production. Thus under the scheme of low cost cultivation machinery research for mechanisation, a paddy winnower suitable to the local conditions is immediate need in Fiji.

In the year 1969 after the introduction of new varieties of paddy the production of paddy has gone up much higher compared to that of the past years. With the increase of yield and unfavorable weather, the farmers in paddy growing areas find handling of paddy winnowing in time difficult and uneconomical. This necessity has made a great demand for winnowers which can separate the fine straw from the threshed paddy and thus can give clean grains.

## Materials and Methods

The main principle involved in the design of this machine is using a centrifugal force of air which comes from a fan driven by a suitable prime-mover. The prime-mover at the moment being used with this machine is one horse-power electric motor coupled with a fan. The fan is enclosed in a tubular structure which blows off the air upward at a slating angle. The tubular structure is metallic and is covered from all the sides and at the bottom at one side it has a gate (adjustable type) for regulating the velocity of wind being sucked from outside by the fan. Most of the materials used in the fabrication of this machine are indigeneous. Iron sheets were used for the whole of structural construction and for frame work iron flats and angles have been used.

The winnower consists of the following functional components : air blower, air tunnel, screen, grain inlet, grain outlet, straw outlet, air regulating gate, and a prime-mover.

Through the grain inlet the grain containing the straw is fed on the screen which restricts the entry of the straw into the system. The air is blown through the tunnel from the fan which blows off the straw and other trashes and separates the clean grain.

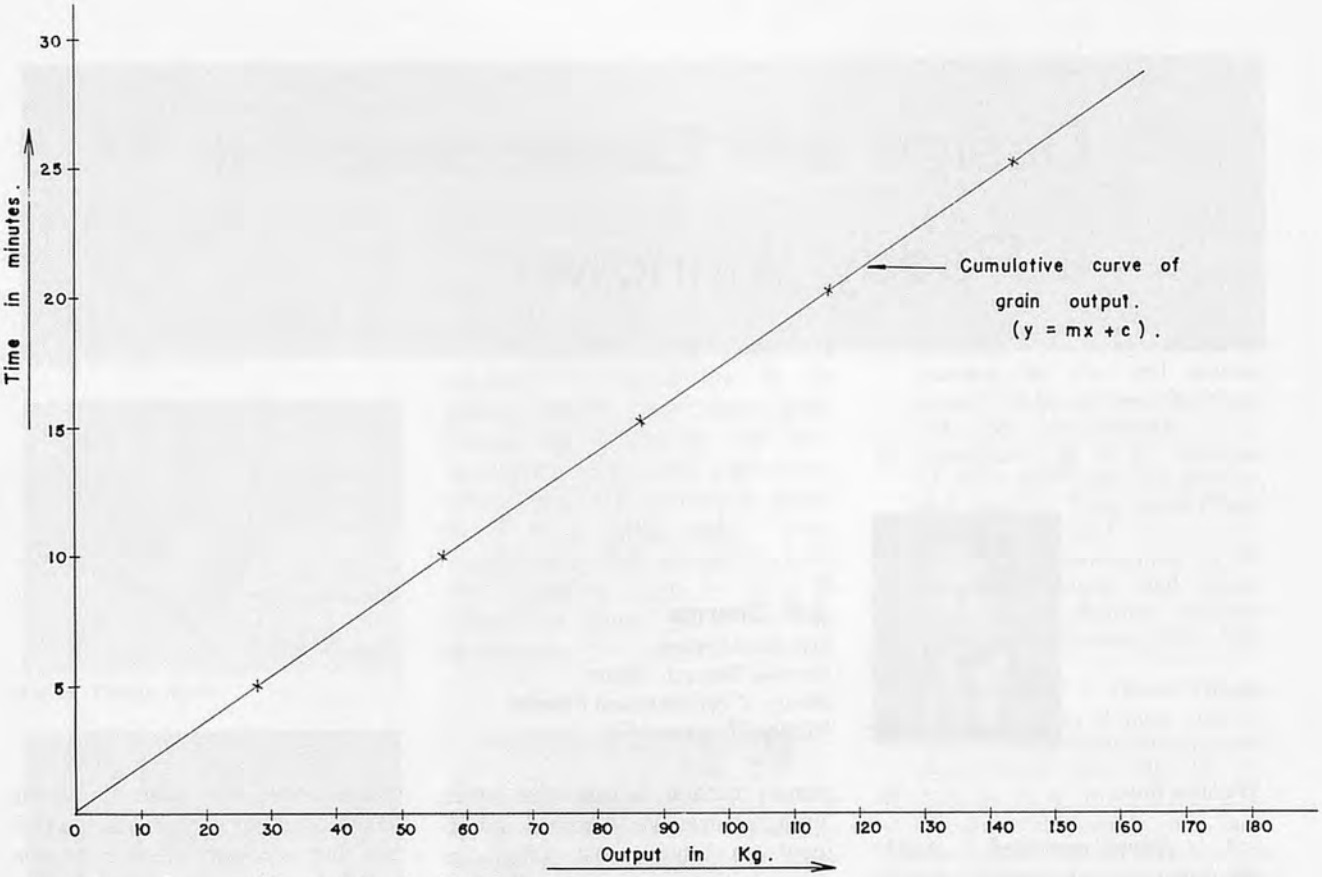


Fig.1 The performance characteristics of paddy winnower

The clean grain keeps on falling in a bag through the grain outlet. Straw and trashes are blown off through the straw outlet.

## Results and Discussion

A series of tests were conducted with this machine on the winnowing of paddy both at station farm and at farmers field. The results found were quite encouraging. The table below gives the details of tests conducted.

From the results available it was observed that as an average the winnower has an output of 350 kgs/hr. of clean paddy under normal conditions of operation.

Table Winnower test

| Test No. | Cumulative Time of Operation (minutes) | Output of Clean Grain (kg) |
|---|---|---|
| 1 | 5 | 28.20 |
| 2 | 10 | 56.30 |
| 3 | 15 | 86.50 |
| 4 | 20 | 117.50 |
| 5 | 25 | 143.50 |

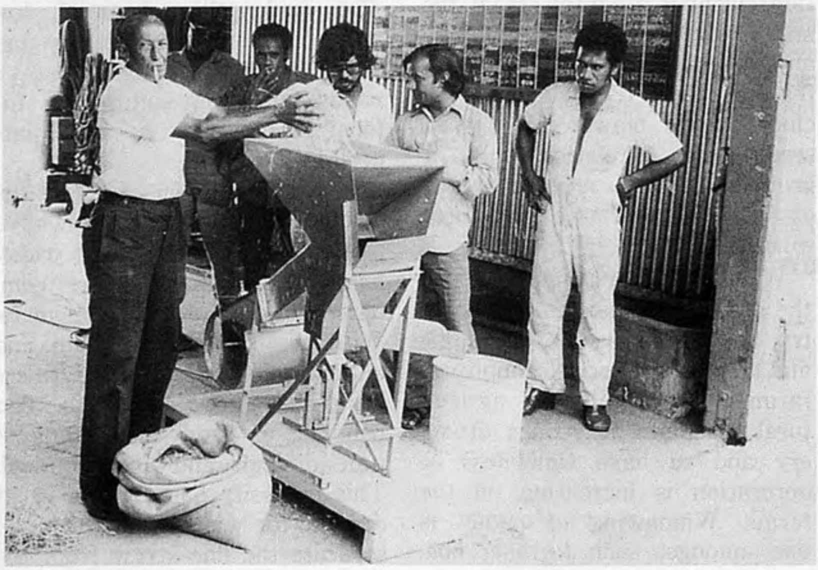

Fig.2 Paddy winnower

However, the output can be increased further if the rate of feeding is increased. Fig. 1 gives the straight line (Y=mx+C) curve of Winnower output when these observations were plotted to study the performance characteristics of the machine. ■■

# Development of a Single-Row Safflower Harvester

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## Introduction

Safflower has acquired the requtation of being drought resistant and suitable crop for dry areas in Western M. P. where clay soils with their good water retention capacity hold enough soil moisture for successful cropping of safflower in rabi season. The deeply penetrating root is able to extract water from such greater depths han the majority of other crops.

Though this crop is promising, due to its spiny characteristics of the leaves, Indian farmers who still use a sickle to harvest the crop experience difficulty.

The use of large-sized harvesting machinery is limited in India because of small holdings, lack of capital and rare facilities for repairs.

Therefore, it was thought that a small harvesting machine that will reap safflower faster and more efficiently than the traditional Indian sickle, and one that is within the financial reach of an average dryland farmer would be a most desirable and practicable advancement in the field of harvesting in India.

※The machine was designd and fabricaticated at the Research Station, Research Branch, Agriculture Canada, Swiftcurrent, Saskatchewan, Canada, under the All India Coordinated Dryland Agriculture Research Scientists Training Programme jointly sponsored by the Canadian International Development Agency and the Indian Council of Agricultural Research.

## Design Considerations

Literature in the field of harvesting shows a direct jump from small hand tools like sickles to machines driven by animals and later by engines and tractors. No attention was paid to the more efficient use of manpower which is economical as well as readily available in India.

Previously, to solve the problem of harvesting, much importance was given either to technical considerations or to social infra-structure. This approach resulted in limited success.

Khanna (1975) suggested a system engineering approach in developing design criteria for a harvesting machine.

While considering the system engineering approach manpower was preferred over animal power or engine power to operate the harvester. For the machine to be cheap, simple and handy, bullock power is not very useful.

Tremendous increase in the cost of gasoline limits the feasibility of use of gasoline engines in India.

## Theoretical Investigations for Energy Requirements

A man normally works at a rate of 7 to 10 kg meter per second. Working continuously he produces about about 8 kg meter per second or roughly 0.1 H. P. (Hopfen, 1969).

Taking 50 per cent as transmission and other losses, the energy available to cut safflower stalk is equal to 0.05 H. P.

Fisher et al (1957) developed an equation which related the diameter of the stem of several forage plants with the energy required to cut the stem.

The equation developed for the stem of Reed canary at 76 per cent of moisture content is given below. For estimating the energy to shear one single stalk of safflower, this equation was used. However, special hardness factor of 10 was taken.

$$E = 0.106 - 0.210D + 20.4D^2$$

where E = Energy (inch pound)

D = Diameter of stem

(inch)

Taking the diameter of safflower as 0.5 inch and substitutiong the value in the above equation,

E = 0.425 ft. lb.

Taking hardness factor 10 for safflower stem,

Energy required to cut safflower stem = 4.25 ft. lb.

Therefore H. P. = 0.008

Hence, it was considered that human power would be sufficient to operate this machine.

The harvester was designed on the basis of the following functional requirements :

1) It must be able to cut safflower stalk which is generally thick and hard.
2) It should maintain the height of cut at 7.5 cm.
3) It should windrow to either side of the machine.
4) It must be able to take quick turns in the field.

### Description of the Machine

The single-row safflower harvester **(Fig. 1)** is a push type machine which is operated by human power. The frame whch supports the ground wheels, components of power transmissin system, the two circular blades and handles is made of rectangular steel tubing. Each groundwheel transmits power to the set of bevel gears which in turn transmits power to one circular blade through sprockets and chain.

Differential action is provided by driving each alade independently, thus allowing sharp turns.

Two pairs of handles are provided at the rear end of the machine to guide and push the machine.

The details of materials of construction are illustrated in **Table 1**.

The functional components of the machine are as follows :

1) Guide and flap : The guide on one side and the flap on the other side direct the safflower into the cutting unit.
2) Cutting unit : The cutting unit consists of two circular saw blades, each of 15 cm in diameter. These two blades rotate in opposite directions. The ratio in bevel gears (3 : 1) and further ratio in the size of the front sprocket (3 : 2) gives a 4.5 times greater speed than the groundwheel.
3) Device to control height of cut : Two rubber tire wheels in each side are provided in front of the machine which help in maintaining the height of cut at 7.5 cm. throughout the harvesting operation.
4) Windrowing shield : As one of the main functions of the machine is windrowing, a windrowing shield made of galvanized sheet was provided above and behind the circular blades. The shield is inclined at an angle of 120° from horizontal. This shield essentially consists of two pieces which are welded at an angle 90° **(Fig. 1)**. This shield and the hinged flap

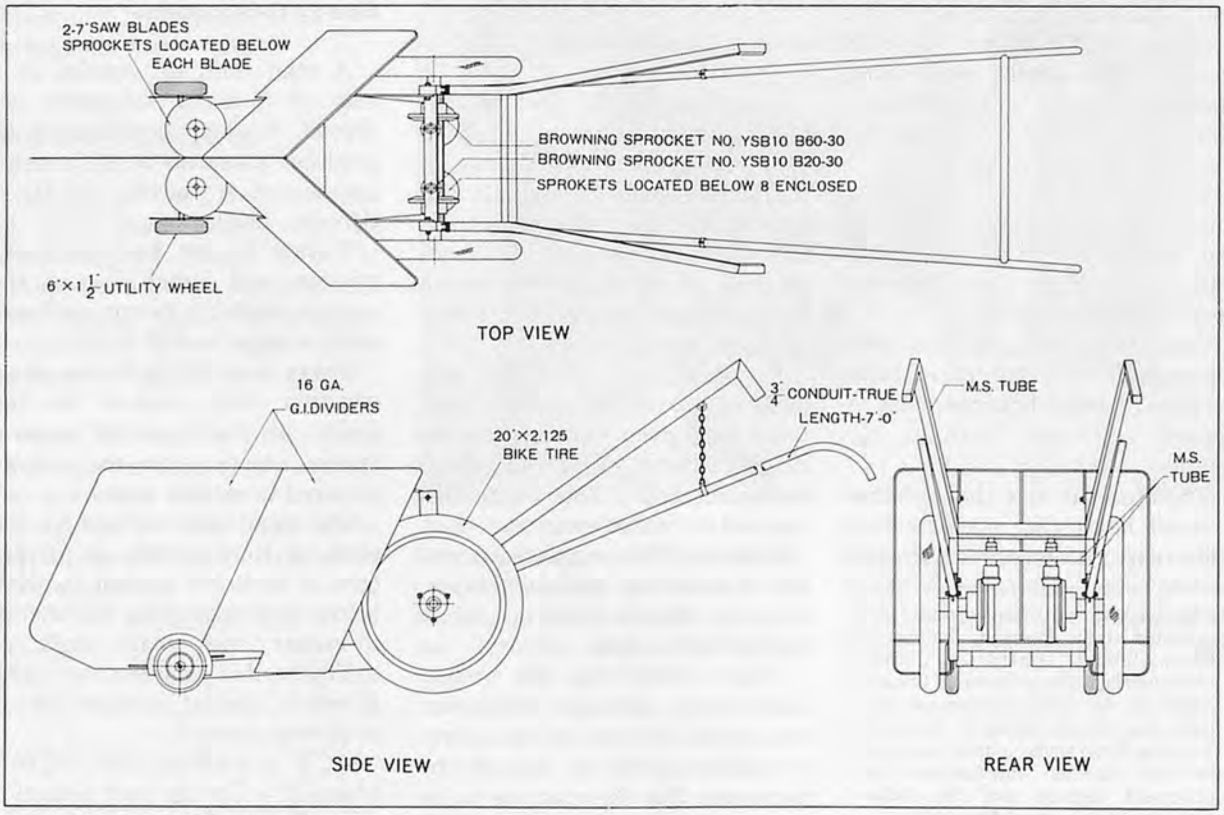


**Fig. 1** The single row safflower harvester

make windrowing possible on either side of the machine. The fiap is moved to the alternate side to change the windrow from one side to the other.

## Test Report

Place : O.T.C. area, Agriculture College, Indore.
Crop : Safflower (IC 11839)
Row to row spacing : 45 cm.
Average plant to plant spacing : 15 cm
Average diameter of plant stem : 1.5 cm.
Soil and soil conditions : Medium black soil, day soil conditions with wide and deep cracks.
Power required : Two-men power
Length of run : 5 meters
Cutting ability : Very satisfactory
Windrowing : Flow of cut material is sometimes found obstructed.
Height of cut : 7 to 8 cm.
Area covered : 10 hours/ha.
Remark : The design features built into the present machine reveal distinct possibilities, but some changes are required. The machine resresents a good base for future work.

Table 1. Materials of construction

| S. NO. | Part | Dimension | Number | Material |
|---|---|---|---|---|
| 1 | Bevel gear | Pitch diameter 6" No. of teeth 60 | 2 | Steel |
| 2 | Bevel pinion | Pitch diameter 2" No. of teeth 20 | 2 | Steel |
| 3 | Circular saw blade | 7" diameter No. of teeth 180 | 2 | Steel |
| 4 | Chain | 5-3/4' long Roller chain | 2 | Steel |
| 5 | Chain tightner | 18 teeth sprocket | 2 | Steel |
| 6 | Frame | 19.5" steel tube | 2 | 1" x 2" steel tubing |
| | | 14.75" steel tube | 2 | 1" x 1 1/2" steel tubing |
| | | 30" steel tube | 2 | 1" x 1 1/2" steel tubing |
| 7 | Front sprocket | 30 teeth sprocket | 2 | Steel |
| 8 | Ground wheels | 20" Diameter | 2 | Bicycle wheels with 20" x 2.25" tire |
| 9 | Guide | 13 ft. long rod | 2 | Iron rod |
| 10 | Hinged flap | 2' x 2' | 1 | 20 gauge G.I.Sheet |
| 11 | Handles | (A) 42" steel tube | 2 | 1" x 1 1/2" steel tubing |
| | | 15" steel tube | 1 | 1" x 1 1/2" steel tubing |
| | | (B) 2' long | 1 | 1" conduit pipe |
| | | 6-3/4' long | 2 | 1" conduit pipe |
| 12 | Rear sprocket | 20 teeth sprocket | 2 | Steel |
| 13 | Small wheels | 6" Diameter | 2 | Rubber tire wheels |
| 14 | Windrowing shield | 2' x 2' | 2 | 28 gauge G.I.Sheet |

## REFERENCES


1. Fisher, David A., Kolega, J. J. and Wheeler, W. C. An evaluation of the energy required to cut forage grasses and legumes. Storrs Agricultural Experiment Station, College of Agriculture, University of Connecticut, (Progress Report No. 17). 1957.
2. Hoppen, H. J. Farm implements for arid and tropical regions. F. A. O. Agricultural Development Paper No. 91. Rome 1969.
3. Khanna, S. K. Design considerations of harvesting equipment in multiple cropping. Agricultural Mechanization in Asia, Vol. IV, No. 2. 1973. ■■

# A Description of the Intergrated Rice-Processing Complex of the Kamol Kij Company, Ltd. Thailand

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### Introduction

The Kamol Kij Rice Processing complex in Bangkok is an unique example of technical intergration in the processing of paddy, having as main objective to make an efficient use of by-products directly or indirectly produced as result of the processing methods.

Through a chain of processing practices a more important range of commercial products could be produced, eliminating simultaneously the hazard of the disposal of useless waste.

The description refers to the applied processing cycle only without any reference to the economics involved.

The explanation given is of general and informative nature and is supported by a flow-chart.

The technical team of the Southeast Asia Cooperative Post-Harvest Research and Development Programme at SEARCA is grateful to Mr. Kamchai Iamsuri, Director of Kamol Kij Company, Ltd. for his cooperation in allowing the author to produce this workshop support material and for hosting the participants of the workshop during a field trip to his integrated rice processing complex on 10th January, 1978.

※ Presented at the Post-Harvest Workshop held in Bangkok, Thailand on January 10 to 12, 1978.

### Description

1. The main activity of the Kamol Kij Company, Ltd. is rice milling. The rice milling capacity is represented by three independent conventional type rice mills using under runner disc hullers for the de-husking and whitening-cones for the multipass whitening. The total paddy intake capacity of the three locally manufactured rice mills is about 400 ton per day for continuous operation. The two old mills have a paddy intake capacity of about 100 tons per day each.
   The capacity of the new mill is about 200 tons per day.
2. The paddy is locally purchased and delivered to the rice mill by boat or truck.
3. About 50 percent of the purchased paddy is processed without being parboiled.
4. The paddy to be parboiled is :
   —Soaked in hot water for about 2-4 hours.
   —Steamed in trucks (parboiled) for about 15 minutes.
   —Dried on cemented sun drying floors or in mechanical driers of the L.S.U. type.
5. The sun drying floors and the mechanical driers are also used for the drying of paddy before storage, even when not parboiled.
6. The rice mill produces :
   —milled rice
   —bran
   —husks, and
   —impurities.
7. The milled rice is graded into :
   —headrice
   —large brokens
   —medium brokens
   —small brokens, and
   —brewer's rice.
   All these five products are final products for marketing. However, the small brokens and brewer's rice can also be absorbed by the feed mill when the market price of these products is not attractive.
8. The bran of the rice mills is sent to the rice bran oil extraction plant. The extraction plant produces two important products namely :

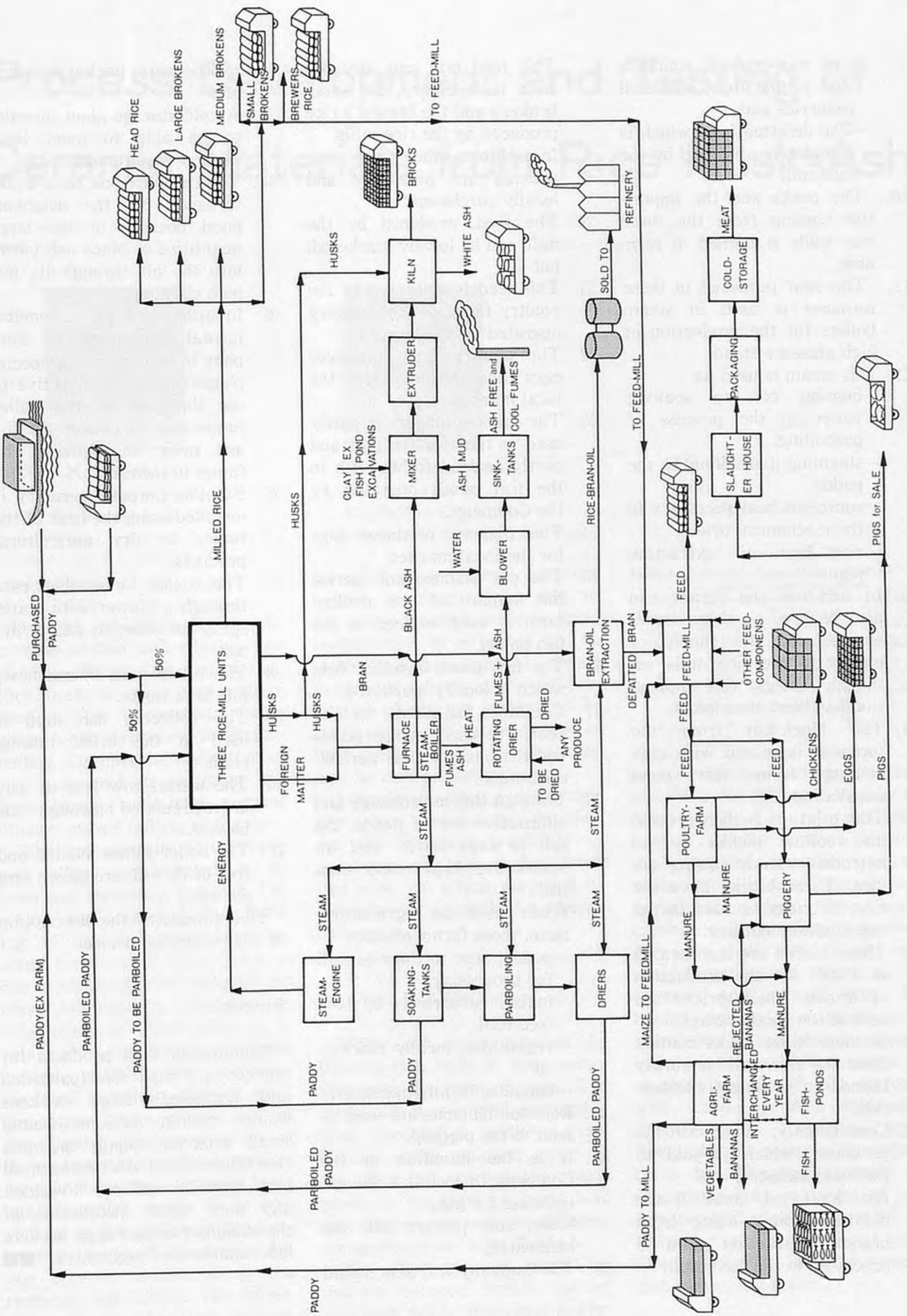


Fig.1 Flowchart of technical integration at the ricemill complex, Kamol Kij Co., Ltd.

9. —The rice-bran-oil which is sold to the local edible-oil refineries and
—The defatted bran which is completely absorbed by the feed mill.

10. The husks and the impurities coming from the three rice mills is burned in furnaces.

11. The heat produced in these furnaces is used in steam boilers for the production of high pressure steam.

12. This steam is used for
—heating of the soaking water in the process of parboiling.
—steaming (parboiling) of the paddy.
—source of heat pecessary in the mechanical driers.
—rice bran oil extraction plant.

13. In addition the steam can also be used to drive steam engines for the supply of energy to the rice mills, although recently this application has been abandoned.

14. The black-ash from the furnaces is mixed with clay coming from fish pond excavation.

15. This mixture is then pressed into hollow blocks by an extruder with a cutting device. These blocks have the size of bricks as used in the construction industry.

16. These blocks are then heated in a kiln for the production of bricks. These bricks are sold at the local market.

17. In these kilns, husks coming from the rice mills is slowly burned to complete combustion.

18. Consequently, white-ash is produced, which is sold to the local industry.

19. As mentioned under 9 the defatted bran coming from bran-oil extraction plant is processed in the feed. mill.
This feed mill can also absorb, if necessary, the small brokens and the brewer's rice produced by the rice mills.
In addition, other feed components are necessary and locally purchased.

20. The feed, produced by the mill, can be locally marketed, but—

21. This feed is also used in the poultry farm and the piggery operated by the company.

22. The poultry farm produces eggs and broilers for the local market.

23. The chicken manure is partly used as feed for the pigs and partly as feed for the fish in the fish ponds operated by the Company.

24. The piggery produces pigs for the iocal market.

25. The pig manure and partly the manure at the poultry farm is used as feed in the fish ponds.

26. The fish ponds produce fish, which is locally marketed.

27. The large fish ponds, for one year, are used as fish ponds and the next year as agricultural farm.

28. Through this interchange and alternatfve use of ponds, the soil is kept fertile and diseases are kept under control.

29. When used as agricultural farm, these farms produce
—paddy, sent to the rice mill for processing.
—maize, absorbed by the feed mill
—vegetables, locally marketed.
—bananas, locally marketed

30. Rejected bananas are used as feed in the piggery.

31. It is the intention of the Company to install a slaughterhouse for pigs.
When this project will implemented,

32. The company will also install a processing packaging plant and

33. A cold storage plant in order to be able to meet local market requirements.

34. The complex has been a disturbance for the neighborhood because of the large quantities of black-ash blown into the air through its five high chimneys.

35. In order to improve enviromental conditions, the company is now installing special plants having as objective to use the heat of the boiler fumes and to collect the fly-ash prior to blowing the fumes in the air.

36. For this purpose a rotary is installed using the heat of the fumes to dry agricultural products.

37. The cooled fumes then pass through a blower with water spray in order to catch fly-ash.

38. The water with fly-ash fiows into sink tanks.

39. The collected ash mud is used in the brick mixing plant.

40. The water, now free of ash, is recirculated through the blower.

41. The boiler fumes, cooled and free of fly ash, are blown into the air.

This completes the description of this integrated project.

#### Summary

Commercial final products for marketing : head rice (parboiled and parboiled) large brokens (same) medium brokens (same) small brokens (small) brewer's rice bricks white ash rice bran oil (not refined) feed for livestock pigs pork (after installation of the slaughter house) eggs broilers fish bananas and vegetables ■■

# Process Development and Testing of Ceramic Materials from Rice Husk-Ash


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## Introduction

One-fifth of paddy by weight consists of rice husk which is the largest milling by-product of rice. Rice husk is being increasingly used as fuel to generate steam either for motive power or for par-boiling. Commercial utilization of rice husk and its resultant ash from burning will have a great impact on rice milling economy.

Rice husk contains 15 to 18 per cent silica concentrated in its inner and outermost surfaces. The white ash obtained by burning of the rice husk contains about 95 per cent silica. Silica is one of the basic raw materials in glass and ceramic industry. Besides glass in which silica is a principal ingredient, various ceramic articles like potteries, electrical porcelain, sanitary ware and other white wares contain considerable amounts of silica in their compositions. Silica used in ceramic industry is obtained from quartite which meeds to be pulverised to fine powder. The temperature required for firing various ceramic bodies is in the range of 1000–1300°C. The advantages of using rice husk ash are that (i) it is obtained in very fine powder from and does not require further grinding ; (ii) due to its more reactive nature, firing temperature is expected to be lower than those used at present in ceramic industry ; and (iii) production of ceramic bodies will be much cheaper, if the liberation of heat energy from rice husk can also be utilized simultaneously.

Accordingly, the present project was taken up to find out the fechnical feasibility of preparing ceramic bodies from rice husk ash which may find its ultimate use specially for electrical insulators.

## Materials and Methods

White ash was obtained by burning rice husk in open atmosphere in the form of heap. The white ash was mixed thoroughly with the other additives like sodium oxide, calcium oxide in the from of carbonates, boric oxide in the form of boric acid and alumina as such in different compositions as listed **Table 1.**

The flow process chart for making ceramic bodies out of rice husk ash is illustrated in **Fig. 1.** Raw materials were first fired

**Table 1.** Different compositions selected for testing their properties

| Composition No. | Percentage | | | | |
|---|---|---|---|---|---|
| | White ash | $Na_2O$ | $B_2O_3$ | $Al_2O_3$ | CaO |
| 1 | 75.0 | – | 15.0 | 5.0 | 5.0 |
| 2 | 80.0 | 10.0 | – | 5.0 | 5.0 |
| 3 | 87.5 | 7.5 | – | 2.5 | 2.5 |
| 4 | 75.0 | 15.0 | – | 5.0 | 5.0 |
| 5 | 95.0 | – | 5.0 | – | – |

at temperatures varying from 800 to 1000°C for different lengths of time (1–4 hrs.) in an electrically heated chamber furnace depending upon their specific composisions. Partially fused masses obtained after first firing were crushed and ground to fine powder in a ball mill. Those fine powder was sieved though a 212 microns and mixed with the binder (sodium silicate) very thoroughly. Then mixed masses were pressed to desired shapes at a pressure of 300–400 kg/cm$^2$ with hand operated hydraulic press. Pressed specimens were then dried at room temperature for a day. The final sintering of specimens was carried out at temperatures ranging from 700 to 900°C for various lengths of time (1–4 hrs.) and the specimens were then cooled gradually.

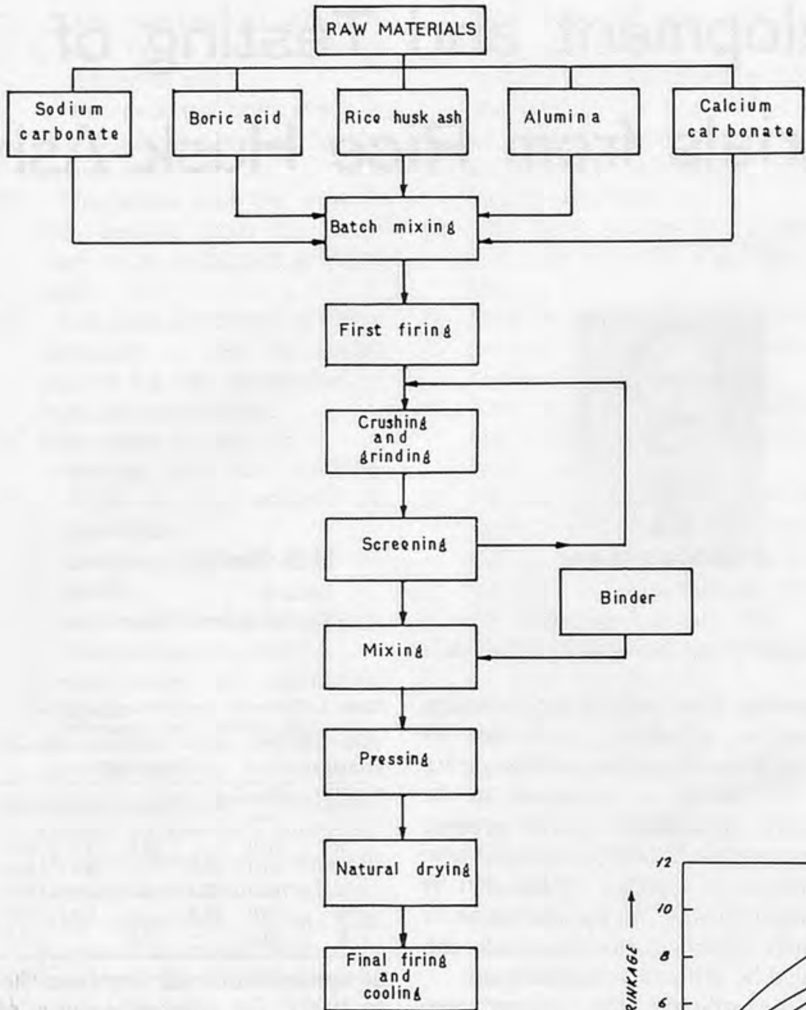


Fig.1 Process flow chart for making ceramic bodies from rice husk-ash

## Result and Discussion

On the basis of preliminary experiments, the compositions 4 and 5 were discarded due to their very low and excessive high melting point. The prepared specimens from compositions 1, 2 and 3 were tested for their physical mechanical, electrical and chemical properties.

*Physical Properties*— The percent shrinkage, bulk density, and porosity of the prepared specimens were plotted against sintering temperature and time as shown in Figs.2, 3 and 4 for different compositions. In compositions 1 and 2, bulk density increased with the sintering temperature but decreased at temperature beyond 775°C and 750°C, respectively. Shrinkage property behaved as that of bulk density while porosity has a reverse trend (Figs.2 and 3). According to the sintering and modification theories, bulk density should increase continuously with temperature as well as time with a resultant decrease in porosity. However, decrease in bulk density at higher temperature may be attributed to the fraction of liquid layer on outer surfaces of the specimens suring the sintering process which prevented the escape of gases resulting in increase of the porosity.

In the case of composition 3, behaviour was quite different from compositions 1 and 2 as shown in Fig.4. Bulk density decreased with the increase of temperature up to 815°C, then increased with the increase in sintering temperature. In this case, first firing temperatures

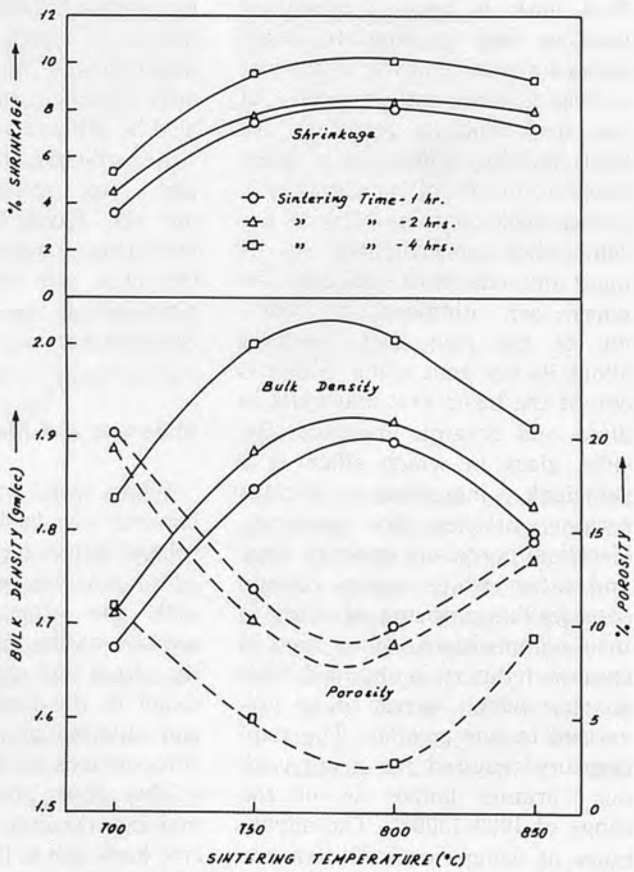


Fig.2 Sintering characteristics of specimens of composition 1

were not enough to drive out all the volatile matter because it contained less quantity of fluxes (12.5 percent) as compared to 25 percent and 20 percent for the compositions 1 and 2. No liquid layer on the top surface of the specimen was observed up to 1000°C for the composition No.3.

*Mechanical Properties* — Mechanical strength of ceramic bodies depends largely upon the internal structure, density, porosity and grain size of the specimen. Modulus of rupture and Young's modulus were determined by three-point bending test with the help of instron machine. These values are tabulated in **Table 2.** Modulus of rupture and Young's modulus varied from 215 to 360kg/cm$^2$ and $1.3 \times 10^5$ to $3 \times 10^5$kg/cm$^2$, respectively.

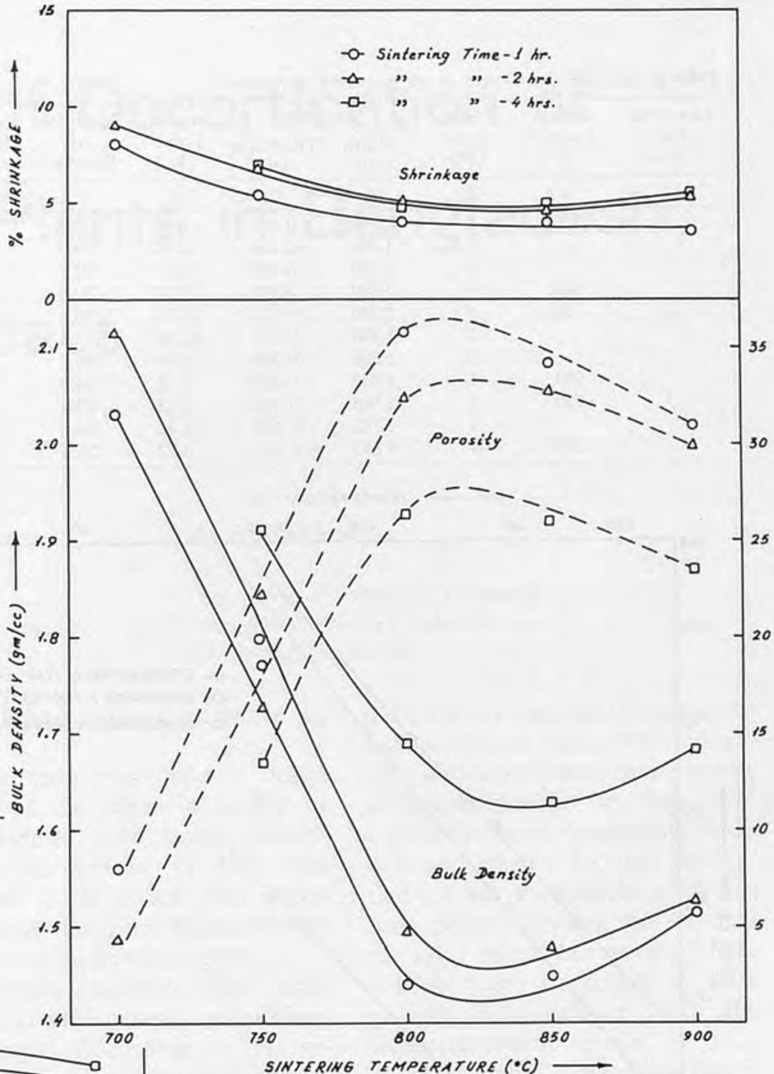


Fig.4 Sintering characteristics of specimens of composition 3

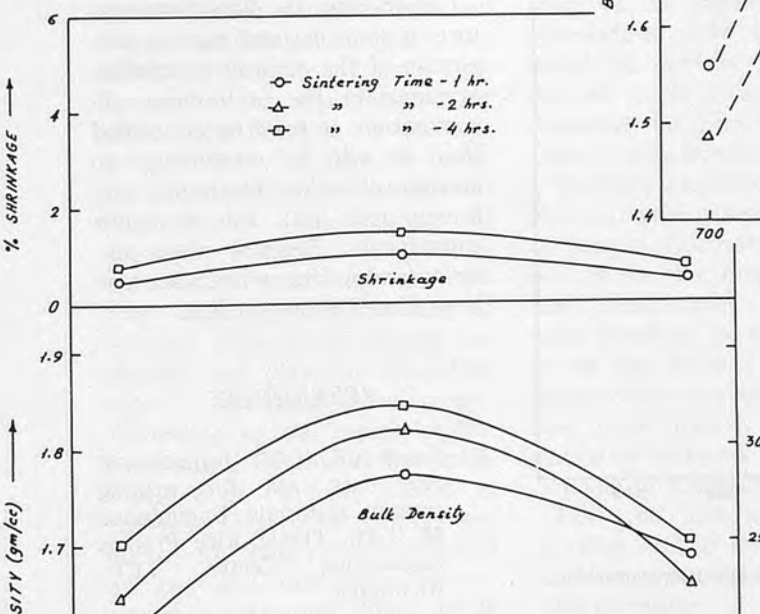


Fig.3 Sintering characteristics of specimens of composition 2

*Electrical Properties*— Electrical resistance of these ceramic specimens was determined by using simple Ohms Law with the help of electrometer and milliohm megameter. Resistivity of the compositions 2 and 3 is lower than composition 1 due to their electrolytic nature arising out of sodium ions. The resistivity decreased with increasing temperature and resulted in a linear relationship between logarithim of resistivity and inverse of temperature as shown in **Fig.5.**

*Chemical Properties*— The specimen prepared in the present investigation were highly resistive to normal atmospheric conditions and dilute mineral

Table 2. Mechanical strength of the prepared specimens

| Composition No. | Final Temp. ℃ | Firing time (hr) | Specimen Width (cm) | Specimen Thickness (cm) | Breaking Load (kg) | Modulus of Rupture | Young's Modulus kg/cm² × 10⁵ |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1 | 750 | 4 | 1.752 | 0.457 | 8.90 | 215.3 | 2.43 |
| | | 2 | 1.789 | 0.559 | 12.62 | 228.5 | 1.53 |
| | | 1 | 1.820 | 0.453 | 12.32 | 291.7 | 2.66 |
| | 900 | 1 | 1.892 | 0.384 | 5.70 | 180.6 | 2.00 |
| 2 | 750 | 4 | 1.846 | 0.531 | 14.50 | 246.4 | 2.88 |
| | | 2 | 1.880 | 0.654 | 22.20 | 245.4 | 1.35 |
| | | 1 | 1.860 | 0.569 | 19.82 | 290.8 | 1.36 |
| | 900 | 1 | 1.932 | 0.420 | 7.12 | 184.8 | 1.58 |
| 3 | 750 | 2 | 1.800 | 0.395 | 9.82 | 309.4 | 2.83 |
| | | 1 | 1.793 | 0.403 | 13.32 | 359.0 | 2.15 |
| | 900 | 1 | 1.853 | 0.341 | 5.72 | 235.6 | 1.54 |

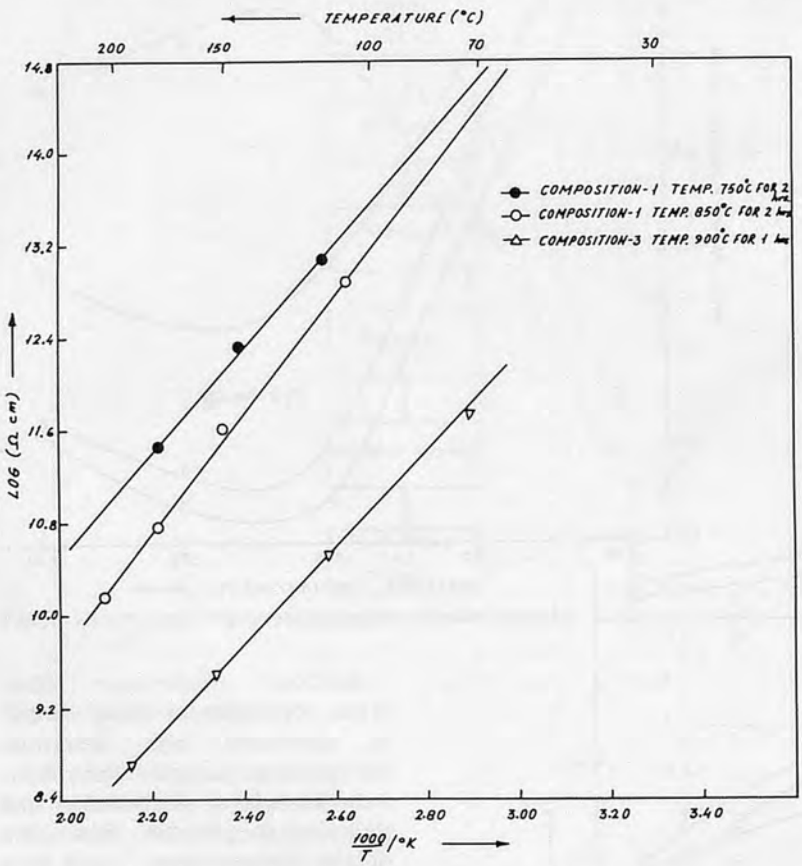


Fig.5 Logarithm of resistivity plotted against inverse of absolute temperature for different specimens

acids. However, an appreciable rate of dissolution was observed in very strong mineral acids like 18 N $H_2SO_4$. The dissolution rate was lowest in composition No.3 and highest in composition No.2.


## Summary

Ceramic bodies using the rice husk ash can be sintered at much lower temperature of 700—900℃ compared to 1100—1300℃ required for conventional porcelain. The density of prepared samples was 1.3 to 2.1g/cc compared to 2.2 to 2.5g/cc for commercial porcelain. Modulus of rupture of samples ranged between 215 to 360kg/cm² although slightly lower than the porcelain ceramic (200—600kg/cm²). Electrical resistivity of the samples containing no $Na_2O$ is extremly high ($7 \times 10^{15}$ohm cm at room temperature) and the material is very much suitable as electrical insulator. The material also has a high chemical resistance towards distilled water as well as mineral acids.

Considering the low temperature of sintering and various properties of the ceramic specimens prepared in the preliminary investigation, it may be concluded that it will be economical to produce electrical insulators containing rice husk ash as major constituents. Besides, tiles, potteries and white wares can also be produced economically.


## REFERENCES


1. Goyal A.K. (1977) Utilization of rice husk ash for making ceramic materials, Unpublished M. Tech. Thesis, Rice Process Engineering Centre, I.I.T., Kharagpur.
2. Kingery, W.D. Introduction to Ceramics. Wiley, New York, 1960.

# Introduction of Decortication of Green Jute Plants in Bangladesh and Its Prospect

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## Introduction

Post-harvest processing of jute in Bangladesh is not at all looked into by agricultural engineers. The system is very old and is not very favourable in consideration of peak labour demand, enviornmental pollution and field efficiency. An investlgation was made into post-harvest decortication of green jute plants.

Jute is the most important cash crop of Bangladesh. By earning a major share of the foreign exchange, jute plays an important role in economic development. According to the report of the Bangladesh Bureau of Statistics, Ministry of Planning, (1978), in the year 1975-76 the country exported Rs. 440. 71 crores worth of jute and jute manufactures which constituted about 79.30 percent of her total exports during that year. An account of annual jute exports is shown in Table 1.

Table 1. Export of jute (excluding export to Pakistan)

| Year | Raw jute Value (Crores) | Jute goods Value (Crores) | Total Value (Crores) |
|---|---|---|---|
| 1968-69 | 74. 94 | 66.04 | 140.98 |
| 1969-70 | 76. 58 | 77.04 | 153.62 |
| 1970-71 | 51. 95 | 72.90 | 124.85 |
| 1971-72 | 49. 45 | 43.27 | 92.72 |
| 1972-73 | 101. 18 | 154.85 | 256.03 |
| 1973-74 | 93. 98 | 158.65 | 252.63 |
| 1974-75 | 75. 67 | 185.87 | 261.54 |
| 1975-76 | 162. 87 | 277.84 | 440.71 |

Bangladesh Bureau of Statistics-1978.

Jute industries hold a large share of the industrial sector of Bangladesh. Jute goods contributed 62 percent of the total amount of jute and jute goods exported in 1975-76(Bangladesh Bureau of Statistics - 1978).

The jute manufacturing trades provide employment to millions of people. According to the report of the jute Enquiry Commission 1960, about 43,000 people were involved in various phases of the jute trade. This number is undoubtedly very high at the present time. Jute is also a good source of revenue for the Government of Bangladesh.

For the individual growers, workers and as a whole, for the country, production of jute is a vital necessity.

Based on the foregoing discussion it can be said that any contribution to raising the quantity and quality of jute is very valuable for the economic development of Bangladesh. So far, very little work is done in developing seed--drill and weeder for jute cultivation but no remarkable work has been done regarding the process of jute after harvesting. Post harvest jute processing in Bangladesh is associated with the following characterstics :

a ) Considerable materials handling,
b ) Unavallability of suitable retting place and water for retting green jute plants,
c ) Seasonal peak labour requirement for retting and stripping,
d ) Low efficiency in the overall process,
e ) Unpleasant odor during retting.
f ) Enhancement of mosquito growth and spread of malaria.

Therefore, to avoid the above mentioned situations, it is justifiable to develop a machine by which the green ribbons can be separated from the green jute plants without breaking the stems.

#### Procedure

A machine was devised for decortication of green jute plants. In this process, the barks were stripped off from the butt ends of the jute plants first by hand. The stems were then passed through the spaces between the bobbins and the barks outside the bobbins. The barks were introduced through two horizontal rubber rollers which were held together by a steel frame. Gears were set at both ends of the rollers so that they rotate in opposite directions. There was also a sprocket at the end of the lower roller. A chain was fitted to connect this sprocket with the sprocket of a bi-cycle frame. A man sitting on the seat of the bi-cycle frame would paddle. Then the rotating motlon is transferred to the lower roller and the upper roller.

The machine was tried experimentally in the laboratory and the results were obtained. In this method, the butt ends of the jute plants were stripped off by hand first. Jute stems were fed into the machine each time. It was found that one operator could ribbon an average of 15 stems per minute with the help of the present machine.

#### Results and Discussion

With reference to the above resuits of the devise the whole operations in connection with post-harvest operation jute processing may be looked into and it can be observed that :

1. In Bangladesh and India, the operations involved in jute processing require the following man-days per acre (after Kirby, 1963) :

a ) Harvesting bundling and carrying to the retting place ······ 14 man-days

b ) Making "jag" etc. ······ 4 man-days

c ) Stripping and washing ······ 14 man-days

d ) Drying, grading and storing ······ 3½ man-days

Total = 35½ man-days

If decortication by machine ribboning is introduced the requirement of manpower may be estimated as :

a ) Harvesting, and carrying to the machine ······ 8 man-days

b ) Placing into the retting tank ······ 2 man-days

c ) Washing ······ 2 man-days

d ) Drying, grading and sorting ······ 3½ man-days

Total = 15½ man-days

If the difference of 20 man-days is required for machine-ribboning of jute plants of an acre, then the minimum rate of ribboning may be calculated as follows :

No. of plants per acre (after Kirby, 1963) = 100,000

Therefore, the rate of ribboning veill be $\frac{100,000}{20 \times 8 \times 60}$ = 10 to 11 stems per minute.

In this context, the performance of the devise was satisfactory, but it should be noted that the butt ends of the jute plants were stripped off first. The time taken for that purpose should also be taken into acount. However, for stripping off the ribbons from the butt ends, aimple device may be designed.

2. The experiment utilized jute plants without branches, although actually, jute plants may be branched sometimes. The branching of jute plants is an adverse quality and the little amount of fibre-loss taking place during decortication may be compared with that taking place in case of hand seperation of fibres from the retted jute plants.

3. Jute harvesting is highly seasonal. The total time for harvesting is 4 to 6 weeks. If the machine lies idle for the rest of the year, in next season, the machine may not be functioning well if care is not taken during idle period. This machine can be made by the village blacksmith and can be casily dismantled and kept in care.

4. In some areas of Bangladesh, jute plants are harvested from under water. The machine is not very big and heavy, and may be used on the deck of a medium-sized village boat.

This experiment is a very preliminary stage in the field of jute decortication. Much research work remains to be done in the future to find a suitable decorticating machine.

### REFERENCE


1. Bradley, J. & Kirby, R. H. (1953-54) Report on investigations into the mechanized prduction of jute and jute substitute fibres. Colon. Pl. Animal Production. 3. 135-164.
2. French-Mullen, M. D. (1960) Experimente in the cultivation, harvesting and retting of jute in British Guiana. Tropical Science 1, 231-285.
3. Covt. of Pakistan : September, 1970. Central Statistical Office, Pakistan Key Economic Indicators ; Volume No.91. p-16.
4. Kirby, R. H. (1963) Vegetable fibres, Leonard Hill (Books Ltd. London.
5. Mazed, M. A.; Design of a device for decortication of urena lobata Fibre ; Report submitted to the Tropical product Institute, September ; 1975 (Unpublished). ■■

# Statistical Modelling of Tapioca Drying in Thailand


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#### Introduction

Good tapioca pellets can only be produced from good chips and to produce good chips, several important parameters have to be controlled, the moisture content being the most important of all. A maximum of 14 percent moisture content is acceptable for Thai tapioca chips except for the months of June and July when a maximum of 14.3 percent is prefered by foreign importers. High moisture content is not desfrable because it constitutes a favourable medium for the growth of bacteria (2). Mahmud and Thanh (1) studied the parameters effecting the drying and pelletizing of tapioca chips to obtain good quality tapioca products. Their study provided a good amount of data on the performance of the various forms and sizes of tapioca chips on various drying media which included solar as well as artificial drying techniques. The present study used the data reported by Mahmud and Thanh (1) and established the various relationships between the parameters by conducting statistical analysis of the data.

#### Drying Technique

The data on the follwing drying techniques were analysed : cement floor drying, black cement floor drying, artificial drying (using a hot plate), shelf drier-a three shelved tray drier : upper shelf (chicken wire), middle shelf (bamboo) and lower floor (wood)

#### Shapes and Sizes of Chips

The tapioca chips of the following sizes and shapes as shown in **Table 1** were investigated by Mahmud and Thanh (1) and the data reported on those chips were used in this study.

**Table 1.** Shape and size of cassava chips

| Shape | Size, cms |
|---|---|
| Circular $CR_1$ | D=4.5, T=0.5 |
| $CR_2$ | D=4.5, T=1.0 |
| Rectangular $RT_1$ | L=8.0, W=2.5, T=0.5 |
| $RT_2$ | L=8.0, W=5.0, T=0.5 |
| $RT_3$ | L=8.0, W=2.5, T=1.0 |
| $RT_4$ | L= .0, W=5.0, T=1.0 |
| Cubic $CU_1$ | L=1.0, W=1.0, T=1.0 |
| $CU_2$ | L=2.0, W=2.0, T=2.0 |
| Stripes ST | L=6.0, W=0.5, T=0.5 |
| Slices SL | T=0.1−0.2 |

#### Procedure

The present procedure included a statistical analysis of the tapioca data between ambient and floor temperatures, drying hours and moisture contente of chips of various shapes and sizes on different drying methods. Regression equations were also developed which predicted the behaviour of the data for their significance at a desired level of confidence.

#### Analysis and Results

The general trend of the data showed that a polynomial of the form $Y = a + b_1 X_1 + b_2 X^2 + \cdots\cdots + b_n \times X^n$ could be fitted to predict the behaviour. Computer programs were thus written to fit a polynomial equation of any order and at the same time to plot the original and estimated data from the model. The computer program was run in IBM 370/145. The regression coefficients were tested for their significance at 95 percent by making analysis of variance and then performing the F-test.

## Ambient and Floor Temperatures

Floor temperature ($T_f$) is highly correlated to the ambient temperature ($T_a$). A second degree polynomial represented the relationship between ambient and floor temperatures for all the drying techniques except for shelf drier (middle shelf) for which third order polynomial was found representative. The relations for the different types are given below :

Cement Floor

$$T_a = 11.71 + 0.632\ T_f - 0.00256\ T_f^2 \quad \cdots\cdots\cdots (1)$$

Black-Topped Cement Floor

$$T_a = 19.15 + 0.289\ T_f + 0.0007\ T_f^2 \quad \cdots\cdots\cdots\cdots (2)$$

Shelf Drier

(a) Upper Shelf (chicken wire)

$$T_a = -38.9 + 3.56\ T_f - 0.042\ T_f^2 \quad \cdots\cdots (3)$$

(b) Middle Shelf (bamboo-net)

$$T_a = -393.95 + 34.85\ T_f - 0.946\ T_f^2 + 0.0085\ T_f^3 \quad \cdots\cdots (4)$$

(c) Lower Floor (wooden)

$$T_a = -26.57 + 2.83\ T_f - 0.0325\ T_f^3 \quad \cdots\cdots (5)$$

Equations (1) to (4) and the experimentl data are plotted in Fig. 1 which shows that the floor temperatures of cement floor, black topped floor and shelf driers (upper shelf) are respectively 33.5℃, 35℃ and 30.2℃ when the ambient temperature is 30℃. The middle and lower shelf of the shelf drier, however, at the same ambient temperature reached temperatures of 29.5℃ and 30.4℃,

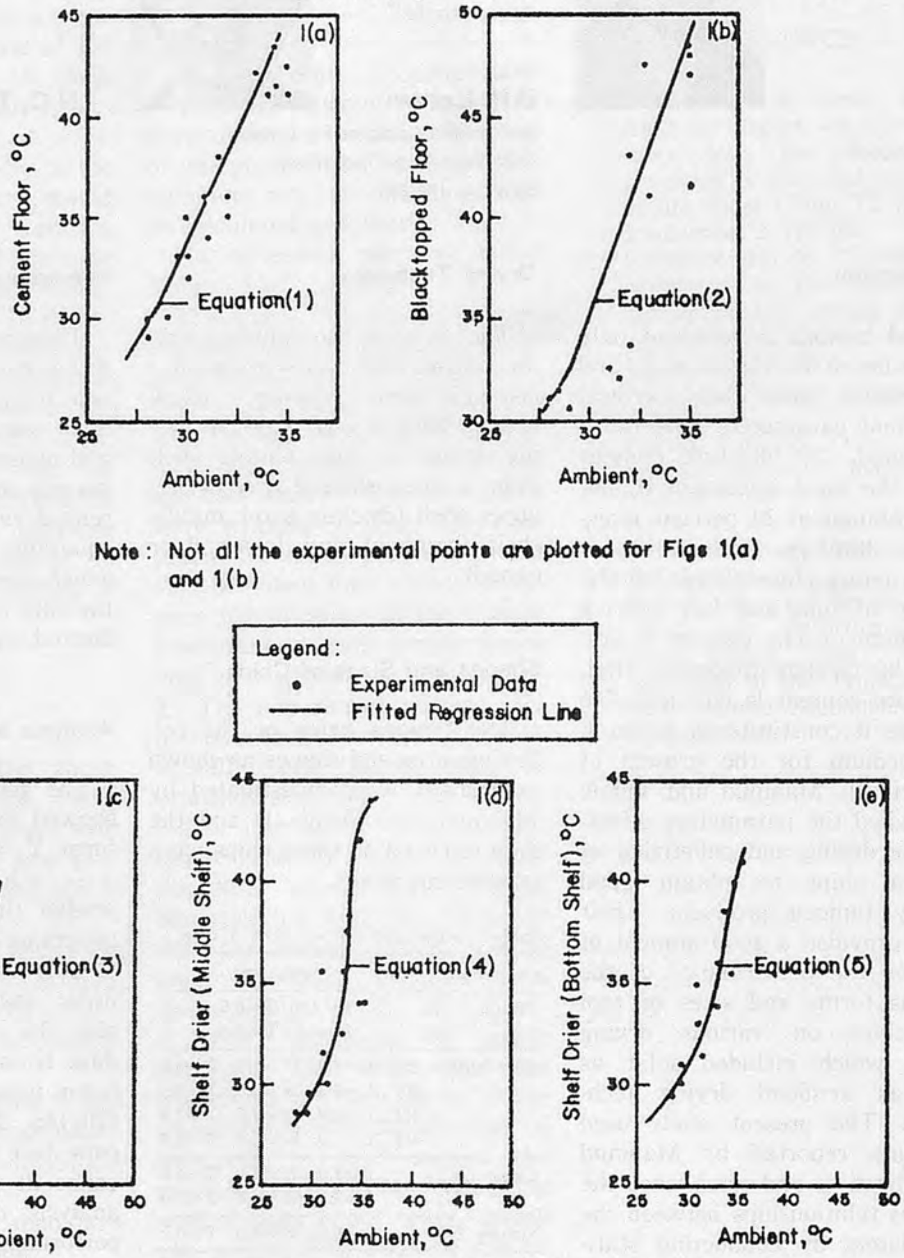


Fig.1 Ambient vs Floor Temperatures for Cement Floor, Black-topped Cement Floor and Shelf Drier

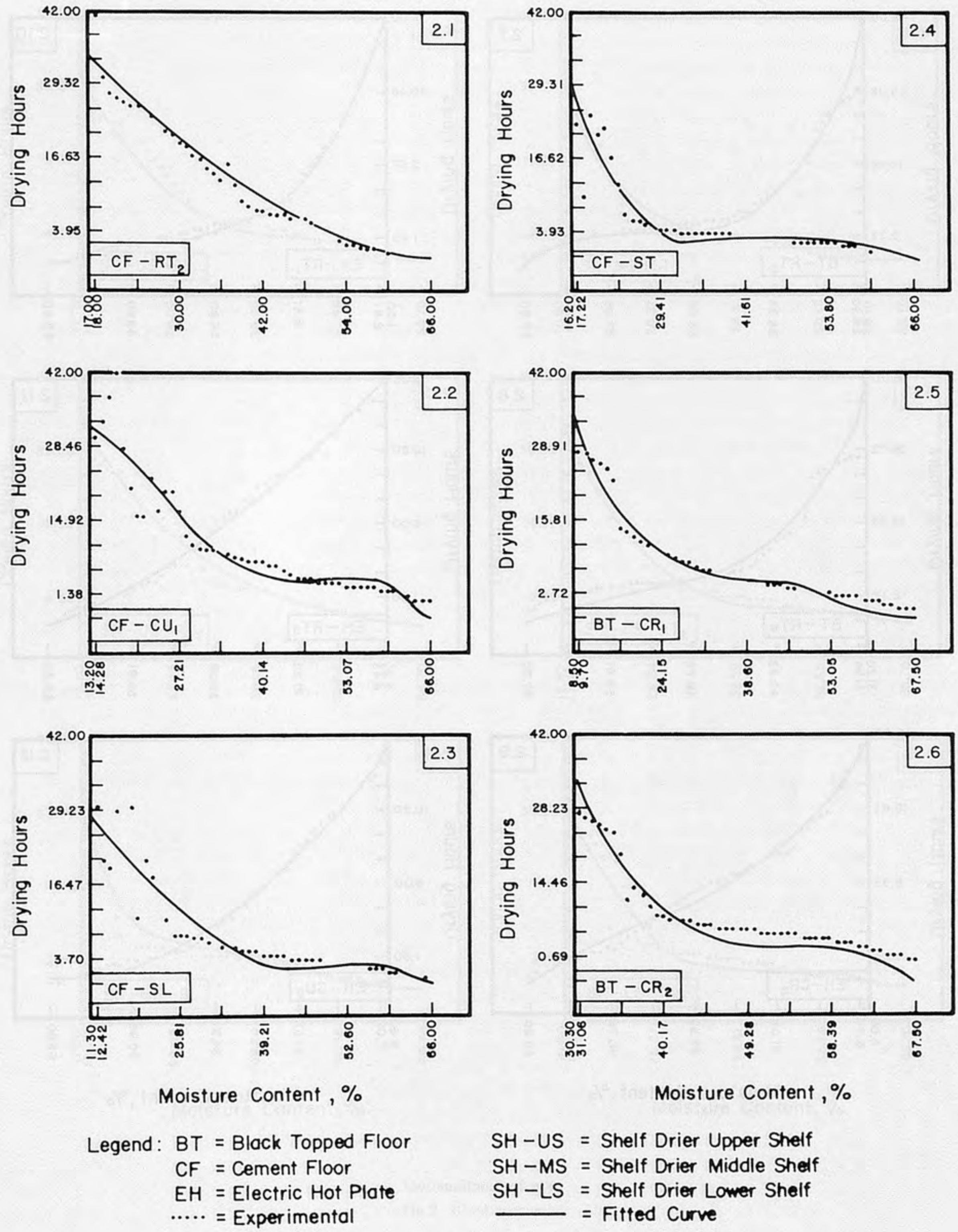


Fig.2 Observed Experimental Date and the Fitted Curve for Some Cases

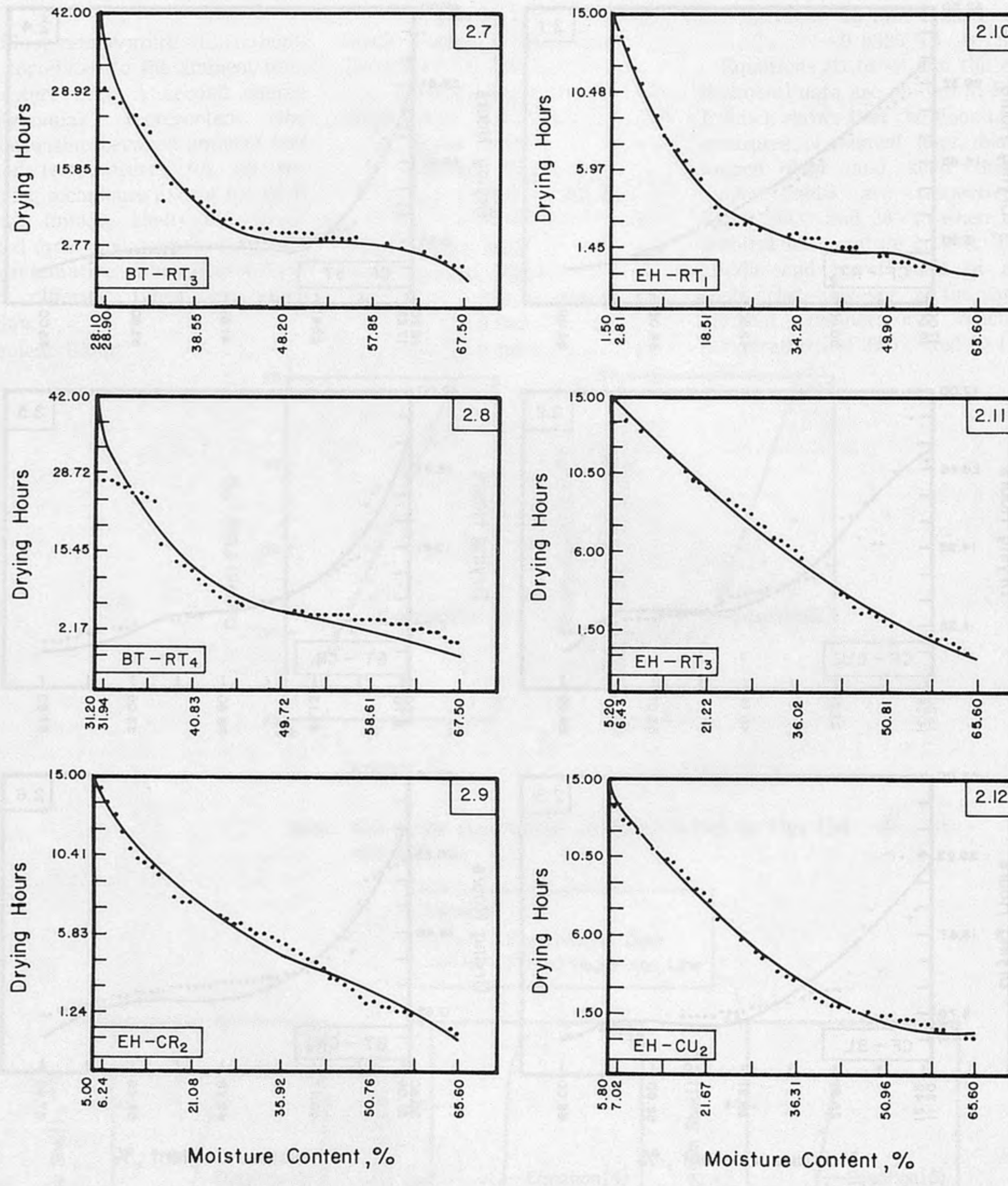


Fig.2 (Continuation)

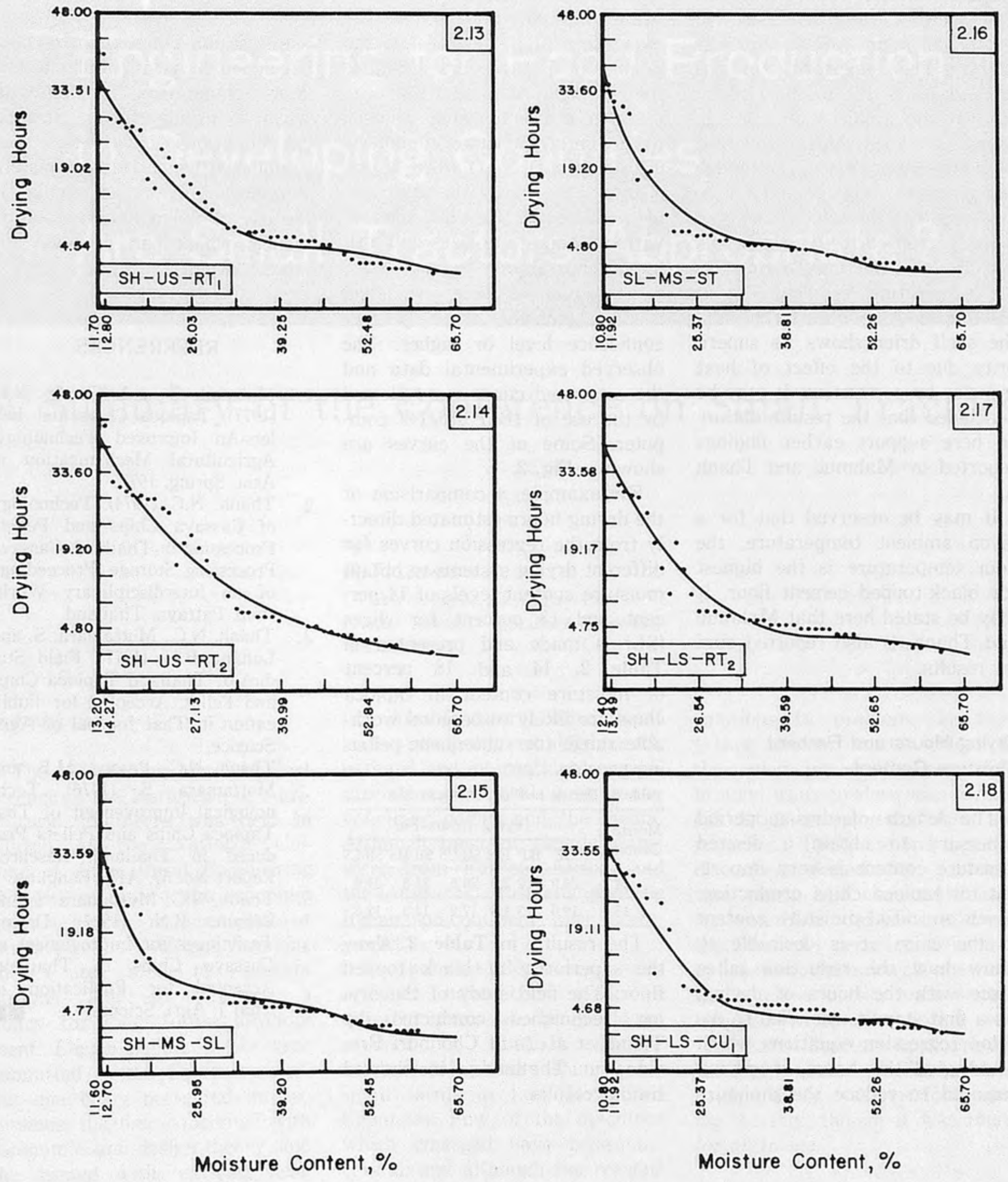


Fig.2 (Continuation)

respectively. However, the performance of the shelf drier in terms of hours of drying was better. The superiority of the shelf drier is due to the circulation of the ambient air through layers of the chips. However, with the floor drying, although temperature may be high, the surfaces of the chips are not equally exposed to the sun's rays. As drying is not only a function of temperature gradient but is also depedent upon air circulation the shelf drier shows its superiority due to the effect of heat transfer by convection. It may be concluded that the results obtained here support earlier findings reported by Mahmud and Thanh (1).

It may be observed that for a given ambient temperature, the fioor temperature is the highest for black-topped cement fioor. It may be stated here that Mahmud and Thanh (1) also reported similar results.

### Drying Hours and Percent Moisture Content

The length of drying period necessary to obtain a desired moisture content is very important for tapioca chips production. Given an initial moisture content of the chips, it is desirable to know how the reduction takes place with the hours of drying. As a first step, it was tried to develop regression equations which could give the hours of drying required to reduce the moisture content of the chips to a desired value. Let $M_c$ and $D_t$ be the moisture content desired and the number of drying hours to reduce the moisture content from the initial to a desired value. That is, if the initial moistrre content is 65.0%, then $D_t = 0$ when $M_c = 65.0\%$. The regression equations were developed for the chips of various shapes and sizes and also for different drying techniques.

The equations were tested and found significant at 95 percent confidence level or higher. The observed experimental data and the estimated curve were plotted by the use of IBM 370/145 computer. Some of the curves are shown in **Fig. 2.**

For example, a comparision of the drying hours estimated directly from the regression curves for different drying systems to obtain moisture content levels of 14 percent and 18 percent for slices (SL) is made and presented in **Table 2.** 14 and 18 percent of moisture content in tapioca chips are likely to be good workable range for subsequent pelleting process.

**Table 2.** Drying periods for slices(SL)

| Moisture Content,% | Drying Hours For | | | | | |
|---|---|---|---|---|---|---|
| | CF | BT | EH | SH-US | SH-MS | SH-LS |
| 14 | 20.9 | 10.2 | 2.9 | 20.8 | 21.3 | 21.9 |
| 18 | 19.0 | 7.3 | 1.6 | 17.2 | 14.3 | 12.0 |

The results, in **Table 2,** show the superiority of black topped floor. The field study of the drying techniques conducted by Thanh et al. (3) at Chonburi Province in Thailand also showed similar results.

### Conclusions

Regression equation have been developed to relate ambient and floor temperaturs for different types of drying media. Statistical equations have also been established which relate moisture content and hours of drying by the use of polynomial regression models which can be used for tapioca drying.

## REFERENCES

1. Mahmud, Z and Thanh, N.C. (1977), Tapioca Chips and Pellets-An Improved Technology, Agricultural Mechanization in Asia, Spring, 1977.
2. Thanh, N.C. (1974), Technology of Cassava Chips and Pellets Processing in Thailand, Cassava Processing Storage, Proceedings of an Interdisciplinary Workshop, Pattaya, Thailand.
3. Thanh, N.C., Muttamara, S. and Lohani, B.N. (1977), Field Studies of Thailand Tapioca Chips and Pellet, Accepted for Publication in Thai Journal of Agri. Science.
4. Thanh, N.C., Pescod, M.B. and Muttamara, S. (1976), Technological Improvement of Thai Tapioca Chips and Pellets Produced in Thailand, Research Report No. 57, AIT, Bangkok.
5. Thanh, N.C., Muttamara, S. and Lohani, B.N. (1977), Drying Techniques for Improvement of Cassava Chips in Thailand, Accepted for Publication in Thai J. Agri. Science. ■■

# Engineering for Food Production in Developing Countries — Are Small Tractors Appropriate?

## A Summary of the Conference on Small Tractors

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### Introduction

The 1978 Spring National Conference of the Institution of Agricultural Engineers was held in March at the National College of Agricultural Engineering (NCAE) to discuss the economic and technical requirements of small tractors ; to see how far these are met by present designs and to propose a policy for their future development. Eleven papers (1-11) were submitted to the Conference, all but one being presented in two sessions, the first concerned with 'economic and design theory' and the second with 'existing designs'. The third and final session was a discussion forum entitled 'How the Present Problems May be Overcome'.

The seriousness with this subject is taken was mirrored by nearly 200 delegates represent-ing a wide range of organisations and countries. The organisations included many of Europe's tractor manufacturers, educational and research establishments, national and international organisations, agricultural consultants, voluntary bodies and the media. Although most of the delegates were from Europe, Africa, and the Americas, Australia and the Indian sub-continent were represented too.

In the last 20 years many attempts have been made in different parts of the world to produce a cheap, effective mechanical power source for small farms in Less Developed Countries. Few of the machines which emerged have been successful, and although the reasons for their lack of success were documented we have still not absorbed the lessons of failure well enough to enable us to overcome them. If we had, this conference would not have been necessary!

Confernces of this kind present information very effectively, but the identification in discussion of solutions to problems is altogether another matter. Most of the papers presented successfully brought us us-to-date with technical detail or suggested new approaches. The outcome of the discussion period, by contrast, was much less clear. Although Ar. von Holst did his best from the Chair to persuade delegates to answer the nectral question, the outcome of the main contributions was to ask another was "Are Small Tractors Appropriate" the right question? The answer to this query was not forthcoming directly, though it was there for all to see.

### Session I. Economic and Design Theory of Small Tractors

It was apparent through the concerence that delgates were happy to define a "small tractor" in one sense as a machine whose nominal engine power output was less than 15 kW (20h.p.) That left plenty of scope for variations in design, capability and cost as we were to hear.

The first paper (1) 'Economic Aspects of the Introduction of Small Tractors in Developing Countries–A Philosophy for Small Tractor Development' was presented by Steve Pollard, Economist in the Overseas Department of the National Institute of Agricultural Engineering (NIAE). Pollard and his co-author set out to be provocative. They thought it was generally agreed new technologies for Less Developed Countries (LDCs) must be both appropriate and acceptable in terms of operational and technical suitability, the particular socio-ecobomic environment, and the resources and aspirations of its members. After defining the main attributes of the "Small Tractor" (here not including single axle tractors) they suggested that it had failed to answer the LDCs need for more farm power. The main reasons for this, they thought, were :

1. Lack of a multi-disciplinary approach to the development of the machfne, with little or no consideration of the importance of LDC rural sociology, peoples and politics, agricultural credit, farm management, tropical crops and livestock, soils, machinery manufacture, and so on.
2. More specifically, the small proportion of LDC farms in the 6 to 8 ha size range for which many small tractors have been desfgned : the vast majority (according to admittedly limited data) are much smaller
3. In extensive (of subsistence) farming systems, the vicious circle of low yields and low prices, which greatly restrict or prevent the farmer from investing in any expensive technology.

Many other factors were discussed in an excellent paper. The authors concluded by repeating their philosophy, admittedly not new, that the prime need is for a simultaneous multi-disciplinary approach to agricultural development, coupled with the understanding that economic development takes time, is complex, and requires unique solutions for each country and region.

In the second paper (2) Giles Cattermole discussed the 'Economic, Political and Social Aspects Governing the Success of Small Tractors'. Cattermole looked first at the size gap between the smallest tractors in volume production and the LDC small farm need ; a gap which has widened since the day of the Ferguson TE20 in the late 1940s and has now resulted in most major tractor manufacturers entering into marketing agreements with Japanese tractor manufacturers to extend their own ranges downwards. He looked at the production of small tractors (again excluding single axle types) in Third World countries and concluded that the total of about 10,000 units/annum fell far short of the 1973 UNIDO predicted of 52,000 in 1975 and 181,000 in 1980. Pollard and Morris's contention that small tractors had failed to meet the demand would seem to have been confirmed.

Cattermole went on to discuss the effects of economic, social and cultural, and political factors affecting the uptake of small tractors. From his discussion he then drew up a country 'Profile' of the conditions likely to favour the adoption of small tractors. A comparison of this profile with the observed characteristics of many LDCs then showed, Cattermole considered, that non-technical factors rendered the small tractor an entirely inappropriate answer to the mechanization need in many cases, a conclusion which reinforced the arguments in the first paper.

Peter Crossley followed with his paper (3) entitled 'Theoretical Design of Small Tractors', which to some extent contradicted Pollard and Morris's contention that engineers about a 'blinkered' or one-dimensional approach to design problems of this kind. Crossley briefly considered the characteristics of LDC small farm systems, and identified the need for an increase in available power from 0.04 to 0.4 kW/ha in combination with other inputs. He identified the average farm size as about 3 hectares, and agreed substantially with Pollard and Morris about the integrated approach which should be used to identify an 'Appropriate' technology for increasing the power available on farms.

Crossley went on to discuss in detail the design factors relevant to a small tractor ; engine type, transmission, tractive performance, implement attachment and control, stability and operator comfort. He then considered some economic factors, suggesting that a small tractor should be economically viable where :

1. its output in basic tillage and weeding operations in conjunction with other inputs produced extra income in excess of costs

or 2. tractor costs were covered by the production value from previously uncultivated land whose use was socially acceptable.

The basic design that Crossley proposed from his detailed considerations was based on a work rate in primary tillage of 0.5 ha/day. His parameters were :

mass···············1 tonne
drive tyres 2 size 7.50-16
engine power 9 kW

Such a tractor, he suggested, would be capable of carrying out one primary and three secondary tillage operaqions on a holding of about 30 ha, at an operational cost within the renge £ 32 to £ 60 per ha. This tractor was designed for direct traction in LDCs. Crossley emphasised that careful prior investigation of the economic and social enviroment was vital to ensure that the concept was viable, and that successful operation would, as always, be dependent upon satisfactory technical, economic and extension infrastructures.

The fourth paper, by Francisco Murillo-Soto and Manuel Aguirre-Gandara, disussed 'Large Versus Small Tractors from an Economic Standpoint in Mexico'. The authors reviewed the factors affecting the mechanisation of small farms, many of about 10 ha, in Mexico and arrived at the same conclusions about the need for a fully integrated approach as previous speakers. One interesting difference in the economics of large and small (20kW) tractors in Mexico is that the smallest they have, the Sidena (Belarus) T-25 costs less per kW than tractors of twice and four times its power output. Add to this that doubling or quadrupling the nominal power output of a tractor does not necessarily multiply up its work output in the same proportion, and the authors considered that in their case the small tractor should be more cost-effective than larger ones.

The authors presented a fairly standard method for analysing the cash flow in a farm business in relation to the machinery and cultivation methods used, so that cost/benefit analyses or internal rate or return criteria could be used to select the best technical least cost syptem of mechanising. They rightly reminded us that the decisions resulting from such an analysis would only be as the information put into it, and commented that in Mexico, as in so many countries, there was a serious lack of the necessary data.

This presentation concluded with a short film which compared mule powered tillage with a 3-wheeled small tractor under development in Mexico. This tractor was not mentioned in the paper ; most interestingly it appeared to be very similar to the 3 wheeler desigh developed at the National Institute of Agricultural Engineering (NIAE) adout 18 years ago, and srbsequently tested in a number of tropical environments including the then Northern and Western Regions of Nigeria. The main features of the NIAE tractor were its single large driving wheel at the rear, two small wheels and toolbar at the front with tiller type steering, rear mounted engine of about 7kW, simple and robust transmission alongside the centrally placed operator. It was a logical design, but problems of cost and effectiveness pevented it from being accepted at that time.

Paper five (5) by Peter Barton on 'Changes in the Demand and Design of Small Tractors During the Period 1960 to the Present' was not presented. The paper comments briefly on some of the experimental and production of small tractors during the period and then goes into more detail on the sophisticated Japanese small tractors of conventional layout, and discusses the history of development of single axle tractors. A number of appendices give details of the production, cost and use of small tractors and related equipment in developing countries for which data is available.

The first session concluded with a paper (11) by Frank Inns 'Operational Aspects of Tractor Use in Developing Countries-a Case for the Small Tractor'. Inns suggested that tractor operating costs in developing countries were likely to be at least twice the level experienced in industrialised countries, due to lower serviceability and increased costs of repair. He developed his thesis by extending from accepted developed country tractor operating cost figures to LDC costs using a number of multiplying factors based on the differences in infrastructure and costs between the two environments. This was a hypothetical argument which would to be tested against actual data. The major cost differences suggested, apart from the overall ratio of 1 : 2 in favour of developed countries, are shown in **Table 1.**

Table 1. Parcentage of some tractor operating costs in developed and developing countries.

| Component of costs | Developed | Developing |
|---|---|---|
| Labour | 42 | 2 |
| Repairs | 8 | 53 |

Inns used these figures to suggest that a suitably designed small tractor, made in the country of use, was the solution to the cost problem. Spare parts would also be locally made and therefore cheaper and readily available, he argued. Furthermore the simple tractor would enable slow progress over a broad front in agricultural development to go hand in hand with intensive and perhape highly mechanised plantation type enterprises. The design rationale for the tractor would of course depend on its integration with viable agricultural production systems.

At the end of the session we had been reminded of all the factors which had to be considered in the analysls and design processes for successful farm mechanisation in LDCs. Several different approaches to these processes had been described, but at the same time the scarcity of accurate date relating to the socio-agro-economics of small farm production systems had been high-lighted.

## Session 2. Existing Designs

The conference now went on to hear five papers on existing tractor designs in relation to LDCs.

Arno Gego gave a paper (6) 'Aspects of Size and Concept of Tractors for Tropical Agriculture'. Gego, as one would expect of a Deutz engineer, was committed to the logic and comparative cost advantage of tractors larger than 15 kW in nominal power output. He argued that sharing the use of larger machines was the only economically viable answer to the mechanisation of small farms, giving as examples the characteristics of paddy cultivation in Asia, cultivation of irrigated areas in Egypt, and cultivation of hard dry soils in Africa. Gego's remarks would apply to larger farms, or pooled farms, but did not relate to the problem faced by the Conference. No reference was made to the lack of capital, small fragmented plot sizes, mixed cropping and all the other problems, nor indeed to the pronounced lack of success of machinery sharing or co-operative machinery enterprises in most LDCs. Only in his last but one paragraph did the author admit that most farms would be from 1-10 ha and that these could not use even the smallest tractor of 16 kW to full capacity.

The next paper by Alan Catterick (7) described the 'Tinkabi System' one of the rare stories of gradually growing success. Four hundred units are now in use and have proved financially viable among progressive small scale farmers, mostly in Swaziland. Early models were sold at subsidised cost, but it was not clear whether this was still the case.

The design parameters for the Tinkabi were drawn up after consultation with "...countless people engaged in agriculture throughout the (African) continent...". The intial design concept has changed little. Important details have been refined and improved to correct teething troubles. A rectangular chassis with a wheel at each corner, fuel and hydraulic oil tanks built in, carries the engine and fluid pump. A hydraulic motor transmits power to each near driving wheel. The frame supports a load carrying platform at the front when required, and a mechanical lift system at the rear. A range of implements has been built for ues with the tractor, those needed for essential operations.

The Tinkabi was extensively field tested in Africa and put through a standard tractor test at the NIAE. Summaries of these reports are presented in the paper. There is no doubt that the tractor is not perfect ; there are poblems with the mechanical lift, ploughing with an offset body is difficult, and the maximum noise level to which the operator is subjected is very high. But in overall terms the tractor is successfully contributing to the development of agriculture, albeit in a small way.

The service contract operated by the manufacturing company has had a considerable part to play in the success of the tractors. Servicing is done in the field by vocationally trained mechanics. Major units can be tested, also in the field, by the same mechanics using simple procedures. Units which fail their test are replaced with exchange units, the faulty assembly being taken back to the factory where it is repaired by highly trained fitters and then put back into the Scheme.

J. Bouyer next presented his paper (8) 'The Bouyer Tractor : The Light Low-powered Tractor for Agricultural Work in Hot Countries'. The Bouyer factory at Tomblaine, France, employs about 450 people and produces 25,000 units/annum, at present, mostly single axle tractor for small farms in the hot tropics. When it became clear from the Company's trials that a somewhat larger four wheeled tractor which carried its operator was needed, co-operation was set up for this development work between the French Company for the Development for Textiles (CFDT)., the Centre for Experimentation in Tropical Farm Machinery (CEEMAT) and the Bouyer Company. The tractor was to be manufactured partly in France (the more sophisticated components) and partly in the user country. The design concept included fitting any convenient engine from 12.5 to 25 kW output, using standard type transmission and front axle assemblies and making provision for a front mounted transport tray, drawbar or a simple hydraulic lift package and supplying power off points for rotary tillers and irrigation pumps. A further important proviso was that it should be possible to adapt to the tractor any type of implement that farmers already possessed.

Prototypes were tested in the Ivory Coast, Mali, and Senegal. A larger batch of 70 machines was then put out in 1977 for supervised field testing in seven West and Central African countries. Reports of this experience dicussed in October 1977 encouraged the developers to put a further 200 tractors into the field in 1978. Detailed attention is now being given to the economics of the exercise, perhaps rather late in the development process, although users were said to be happy with the tractor. The importance of operator training and technical backing with spares and service facilities was emphasised.

Here is another case, similar to the Tinkabi, in terms of approach, clearly destined to be successful in its own sphere. The total numbers are still in hundreds, however, way below the projected demand of about 180,000 in 1980 mentioned by Cattermole (2).

Noboru Kawamura's (9) 'The Japanese Small Tractor' was read by Peter Cowell (NCAE). The success of the Japanese single axle tractor is well known, and not surprising in an agriculture consisting of farms typically 0.5-1 hectare in size, over an arable area of 5.615 million hectares, 57 percent in paddy fields of 0.1 ha.

Over the last ten years Japanese production of two wheel (single axle) tractors has declined from 478,000 to 296,000 while the output of small four wheeled tractors has increased from 24,000 to 236,000. Seventy-two percent of these four-wheel machines are of 15 kW or less, clearly in the "small trsctor" category. But these are highly sophisticated machines, designed primarily to power rotary tillers. Four-wheel drive,-three and four-speed power take--off shafts, multi-cylinder high speed engines, complex hydraulic systems are all features of the Japanese machines. Within the constraints of low technology, low yields and low prices, it is difficult to foresee a demand for the small Japanese four wheeled tractor in LDCs Regardless of this the paper gave a fascinating account of the characteristics of the tractors and the agricultural system of which are part.

The final paper (10) of the conference "The AMEX Tractor" was presented by V. J. Dane-Bryan. AMEX is an overseas consultancy firm based at Shaftesbury in England. The author became associated with AMEX in 1975 to develop a small tractor to fill the gap between a good ox team and production tractors of about 26 kW. The main design parameters were :

1. enough power to plough 1 furrow in any conditions
2. simple design and construction with large safety factors
3. 'low' cost-U.S. $ 3,000 was quoted
4. economic operation
5. high design stability to give safe operation.

Traction criteria produced design values for mass, draught and tyre size very similar to those arrived at by Crosslay (3). Design detail was aimed at production or assembly in LDCs.

At first sight the AMEX tractor looks a bit like a dumper truck except that a transversely mounted 12 or 13 kW engine and belt drive transmission takes the place of the hopper, and of course the small wheeled sterring axle is the front of the tractor rather than the back of the dumper truck. Mechanical inboard dics brakes and a simple hydraulic lift system are incorporated with auxiliary power drive taken off the engine crankshaft. The tractor is very compact, having a wheelbase of only 1.17 m and an outside wheel width of 1.0 m. This may well make it an uncomfortable machine in rough ground conditions.

The author claimed that the AMEX gave a high tractive efficiency when ballasted (quite heavily for its size) at the rear. Construction is certainly simple, and the tractor appeared to have potential for operation on small level farms. No production figures, official or tropical test data were available.

The second session described in some detail the development methods which have led to modest success for the Tinkabi and Bouyer tractors. Others could clearly be built on the same lines, but it has taken us a long time even to arrive at this stage in 'Small Tractor' development. What answers could the final discussion provide towards overcoming the proplems we still face.

### Session 3. Discussion Forum on How Present Problems May Be Overcome

The discussion was opened by R. D. Bell, Head of the Overseas Department at the NIAE. He highlighted some of the comments which had been made in the papers, and brought up additional factors for delegates to consider :

1. only a small number of farms would appear to be suited to the 10-15 kW "Small Tractor" concept (Pollard & Morris)
2. servicing problems are greater at low operational densities, perhaps tractor servicing should be coupled to other mechanical operations
3. many small tractors have lacked effective linkages and implements. There was no prospect of success without these
4. it is more severe to use small tractors at full lond than big tractors at part load
5. should small tractors be fitted to agricultural systems, or used as catalysts for development like the Tinkabi?
6. perhaps we should use small tractors with large ones to cover the marketing profit motive.

Following this introduction, the chairman suggested that the key to increasing small farm outputs lay in improving the living conditions of small scale farmers. He then asked delegates to concentrate on answering the central question posed by the conferance, "Are Small Tractors Appropriate?"

Discussion went on long past the time allotted. Many useful contributions arose from the floor. Among them was a comment on the relationship between crop yield and value and the cost of a tractor. It was stated that the quantities of paddy required to fund a small tractor in a range of countries were :

| Country | Ionnes paddy | Land area (ha) |
|---|---|---|
| Japan | 3.3 | 0.7 |
| Sudan | 6 | |
| Nigeria | 12 | |
| Malaysia | 15 | |
| Philippines | 18 | |
| India | 33 | 11 |

No further comment is needed.

Brian Pothecary (Agricultural Engineering Consultant) and C. Uzureau (Director, CEEMAT) considered that the Tinkabi and Bouyer tractors had succeeded in unique environments, implying perhaps that other regions were not so fortunate in possessing the right ingredients for success. Ian Johnson of the Overseas Department, NIAE suggested that successful marketing of single axle tractors in Kenya and the Philippines had been associated with non-agricultural companies.

The Chairman emphasised a delegate's comment that there was still no shortage in many countries of land waiting to be brought into production by suggesting that there was a total area of 225 × $10^9$ hectares in this category. So in addition to increasing production from existing farms a great deal remained to be done in clearing and developing new land. The main limiting factor is still a shortage of energy as Crossley (3) pointed out, developed countries having an input of 0.6 kW/ha compared with much of Africa at 0.04 kW/ha. That energy, of course, could be provided by much larger power units if the overall agricultural organization permitted.

In answer to the central question Boshoff (IITA, Ibadan) struck a blow for the larger unit. He suggested that the developer of a small tractor found two critical questions difficult to answer –

1. What is the size of your maket ?
2. What is the intensity of use of your product ?

In addition the price of the crop and the skill of the farmer were vital factors in the success of small tractors. After many years of involvement in development Boshoff had concluded that as crop prices, farmer skills tractor use intensity all increased, the larger tractor was progressively encouraged.

Overall, however, there was a strong consensus that answers could be found to the engineering problems, but that correct analysis of the many other critical factors of sociojogy, economics, agronomy, production systems and the like was much difficult yet vital to success.

Each country or region would need its own unique solution to the overall problem of increasing production in the most economical way. This would take time, and would only be achieved by the painstaking multi-disciplnary approach.

## CONFERENCE PAPERS


1. Pollard, S. Morris, J. Economic Aspects of the Introduction of Small Tractors in Developing Countries. A Philosophy for Small Tractor Development.
2. Cattermole, C.G. Economic, Political and Social Aspects Governing the Success of Small Tractors
3. Crossley, C.P. Theoretical Design of Small Tractors
4. Murillo-Soto, F. Aguirre-Gandara, M. Large versus Small Tractors from an Economic Standpoint in Mexico
5. Barton, P.S. Changes in the Demand and Design of Small Tractors During the period 1960 to the Present Date
6. Gego, A. Aspects of Size and Concept of Tractors for Tropical Agriculture
7. Catterick, A. The Tinkabi System
8. Bouyer, J. The Bouyer Tractor : the Light Low-powered Tractor for Agricultural Work in Hot Countries
9. Kawamura, N. The Japanese Small Tractor
10. Dane-Bryan, V.J. The AMEX Tractor
11. Inns, F.M. Operational Aspects of Tractor Use in Developing Countries. A Case for the Small Tractor.


## PUBLICATION OF THE CONFERENCE PAPERS

A full report of this conference will be published in the June issue of the "Agricultural Engineer", the journal of the Institution of Agricultural Engineers, West End Road, Silsoe, Bedford, England. MK45 4DU. ■■

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Deputed as Agricultural Engineer (Indian Expert) Under the Colombo Plan of Indian Aid to the Govt. of Fiji to conduct Research in farm Machinery/Mechanization and to advise on Farm Mechanization. w. e. f. June, '76.

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1975-1978 : Assistant Professor of Agricultural Engineering
Asian Institute of Technology, Bangkok, Thailand.
1978 till date : Associate Professor of Agricultural Engineering, Asian Institute of Technology, Bangkok, Thailand.

# NEW PRODUCTS

**Planter**


New John Deere 7000 Conservation Planter extends the benefits of Max-Emerge Planters to minimum-tilled or zero-tilled fields.

Innovations on the new 7000 Conservation Planter — in 4-, 6-, and 8-row models — overcome the poor stand problems that were associated with early model planters intended for use in stalk or sod ground.

Penetration problems have been overcome by using a heavyweight 7 × 7-inch mainframe and by providing adjustable downpressure springs that transfer up to 500 pounds onto each coulter and planting unit, depending on ballast.

Accurate seed placement at the desired depth has been accomplished by attaching a heavy-duty tillage coulter (fluted or ripple) ahead of, and to, each planting unit so its working depth is determined by the same gauge wheels that control planting depth of the Tru-Vee™ openers.

Optional heavy-duty cast iron firming wheels provide the strength and weight needed to close furrows in hard ground conditions and sod.

Electronic seed monitors are available to help ensure planting at the desired population level.

New John Deere 7000 Max-Emerge Conservation Planters will be available to plant four 30- to 40-inch rows, six narrow or wide rows, or eight narrow rows.

(Deere & Company : John Deere Rood, Moline, Illinois 61265, USA)

**Toolbar**

Increasing tractor horsepower has created a need for stronger toolbars equipped with stronger hitches. John Deere has met both requirements with the introduction of the new 50 Toolbar for use on tractors with up to 250 PTO hp, equipped with Category 2 or 3 hitch with Quik-Coupler.

Ground-engaging tools — subsoilers, chisels or a variety of other toolbar-based equipment for 5 × 7-inch toolbars — can be set for almost any spacing on the 50 Toolbar because of a laterally adjustable mast that virtually eliminates "dead spots".

The 50 Toolbar is available in 8- to 30½-foot lengths.

For applications not requiring the strength of the new 50 Toolbar, the John Deere 45K Toolbar stays in the line for use on tractors delivering up to 150 PTO hp.

(Deere & Company : John Deere Road, Moline, Illinois 61265, USA)

**Heavy Duty Washer**


With 750 PSI at 3 GPM, the HPW-3HD is the heavy duty washer for all your cleaning needs.

This heavy duty washer is powered by a 115 volt, 15 amp, 1 h. p. motor and 3 piston pump.

An automatic siphoning system and unloader valve add years of life to the pump and motor. With the automatic siphoning system, cleaning concentrates are mixed with the water after the pump. Only clear water goes through the pump. The unloader valve reduces pump back pressure and motor load when the washer is turned on, but not spraying.

Hand gun features include 3/8" hose, trigger-type control and a four nozzle turret head.

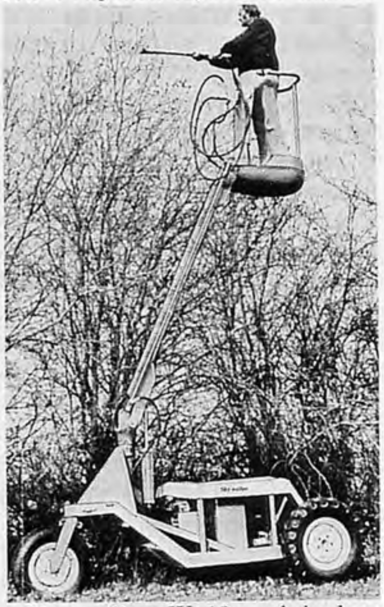
The turret head consists of three stainless steel high pressure cleaning nozzles and one stainless steel low pressure concentrate nozzle. To select the spray pattern needed, rotate the head : 0° to blast away heavy dirt, 15° for average cleaning and 40° for large areas. To apply cleaning concentrate at low pressure, rotate the head to the largest opening. The washer automatically swiches to low pressure and applies the cleaning concentrate.

A three way valve on the front of the washer enables you to apply clear water or cleaning solutions (from a 55 gallon durm or similar container) at 100 or 750 PSI.

Ten inch wheels and 30 foot hand gun hose let you take HPW-3HD anywhere your cleaning jobs may be.

(Gordon Fennell Company : Cedar Rapids, Iowa 52401, USA)

## Self-Propelled Hydraulic Ladder



Sky walker W-18 ··· A hydraulic and hand operated ladder for pruning of trees, with the electric start 16HP Briggs & Straton engine.

This ladder is suitable for operation by a man standing on it for pruning of trees, because its position can be controled by hydraulic system. And with three-wheel style tires for making a small sharp turn, you can easily move it in any small places.

(Specifications)
Hydraulic pump : 12 G. P. M. at 2500 R. P. M., Pressure : 1500 P. S. I., Drive : Hydraulic motor through differential, two speeds 0-2 M. P. H., 0-4 M. P. H., Boom lift capacity : 400 lbs (181 kg), Swing : 39 degrees, Working height : 19'-0" (5.79 m), Basket height : 13'-0" (3.96 m), Basket down : 5'-5" (1.65 m), Width overall : 5'-11" (1.80 m), Turning radius : 7'-1" (2.16 m), Weight : 1850 lbs (840 kg) (approx.)

(Koor Inter-Trade (Asia) Ltd. : Koor Bldg. 8, Shaul Hamelech Ave., P. O. Box 1514, Tel-Aviv, Israel)

## Moisture Tester


Accuracy of any tester for measuring moisture is based on measurements taken in an air oven. The calibration of the INSTO MOISTURE TESTER is based on air-oven measurements. This tester will read from 10% to 40% moisture content with optimum calibration on readings from 10% to 25% moisture content.

The INSTO MOISTURE TESTER uses a standard nine volt transistor radio battery. To replace the battery, simply open the battery cover and remove the battery with thumb and index finger. Then detach the battery from the leads and replace with a new battery. With normal use the battery should easily last for one year. If a sample is left in the testing chamber, the power is shut off automatically in approximately two minutes. It is recommended that the battery be removed when the MOISTURE TESTER is not to be used for several months. Battery is not covered by warranty.

The INSTO MOISTURE TESTER measures 7" × 9 5/8" × 4 3/4" and weighs less than 60 ounces. The electronic circuitry is completely enclosed in a molded plastic case. With normal care and use the rugged INSTO MOISTURE TESTER will last many years.

(Insto Inc. : P. O. Box 113, Auburn, Illinois 62615, USA)

## Area Monitor


The DICKEY-john Area Monitor is a solid state, simple to operate, electronic measuring device that provides you with a direct digital readout of the numbers of acre/hectares being plowed, cultivated, planted, fertilized, or harvested. The Area Monitor can be used with sprayers, spreaders, self propelled equipment, or any implement towed by tractor.

As a farmer and business manager, before you can work your land efficiently, you need to know precisely how much land you are working. The only acreage that counts is the acreage you can harvest.

The Area Monitor is a fundamental management tool. The knowledge it provides can pay off in the form of direct savings at the time of seed and chemical purchases and direct income at the time of harvest.

Your exact acre knowledge will allow you to plan your time more effectively for greater profits.

(DICKEY-john Corporation : P. O. Box 10, Auburn, Illinois 62615, USA)

## NEW PUBLICATIONS

### Introduction to Crop Processing Machinery

(Guyana)

In teaching the farm mechanization aspects of agriculture over a number of years in tropical and developing countries, the author has felt a great need for books written in simple terms so that the subject matter can be "introduced" to students who have grown up in a rural background and are not very familiar with modern machinery and equipment, while most of the existing and sometimes excellent books written to deal with agricultural machinery are authored by experts located in western countries where farm mechanization has become well established and where the present generation of students have grown up in a more "mechanical" background. The author has tried to cover the gap in the field of crop processing by writing a book entitled "Introduction to Crop Processing Machinery", which is being presented in a summary form in this article. Enquiries for publication of the entire work would be welcome from interested publishers.

The primary objective of the book is to introduce to the student the basic principles of the various types of machinery and equipment used for crop harvesting and processing, without attempting to deal either with the details of construction of an individual machine or to make the book appear either as an operator's manual or a maintenance mechanic's guide. Detailed information on these aspects of a particular model or machine is best obtained from the well illustrated instruction books usually supplied by the makers of machinery. A list of selected references has been provided at the end of each chapter which can help the student seeking detailed information on any particular type of machine of operation.

Crop processing covers the various operations that are carried out on the farm from harvesting to the time the crop is consumed or finally disposed of by the farmer. It includes, for example, the operations of harvesting, threshing, cleaning, grading, cutting, mixing and drying, in addition to crop handling and storage. Preservation of crops by methods of canning, freezing, and dehydration are also considered to be a part of crop processing. Of these, harvesting is the last operation usually carried out in the field, while all other operations are carried out in the farmstead or barn. A brief summary of the various operations mentioned above and the machinery used for the processing of commonly grown field crops in tropical countries, as discussed in the text of the book, is provided in the following paragraphs along with selected illustrations.

**Harvesting and Threshing**

The harvesting equipment used by a farmer may vary from a simple sickle and the scythe to a complex self-propelled combine harvester-thresher, depending mainly on the scale of operation and the type of crop. The harvesting equipment considered in the book inculudes the sickle, the scythe, the animal-drawn land-wheel driven or a tractor operated power-driven reciprocating mower, the power driven rotary slasher, the reaper and the binder, the power driven flail-type forage harvester for green grass or dry hay, a root harvester for crops like potatoes, cassava and sweet potatoes which form their edible parts under the soil, the modern combine-harvester which can perform the multiple operations of harvesting, threshing, cleaning and bagging or delivering in bulk in a single pass over the field, and the corn or maize harvester, which is capable of picking either a single or multiple rows at a time.

The threshing of a crop as done either by peasant farmers with little mechanical help or by power operated threshers, along with recent developments in animal drawn threshers like the 'Olpad' equipment is also considered. The specialized equipment required for the hulling or shelling of a grain like rice or maize (**Fig.1**) after threshing or that of parchment coffee is discussed in this chapter.

Fig.1 A hand operated maize sheller-grader converted to a power driven unit

**Cleaning and Grading**

Modern mechanical threshers also clean and grade the grain to varying degrees during threshing, while threshing as carried out by the peasant farmer (**Fig.2**) using simple or no equipment (by beating the crops on the ground) does

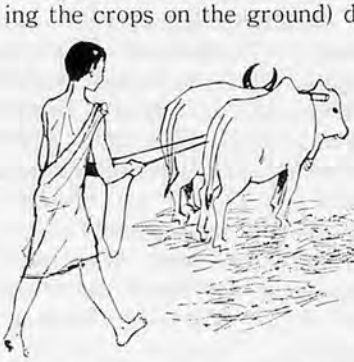


Fig.2 Threshing of a crop by animal trampling on ground

not provide for any cleaning or grading during threshing of the crop. In this chapter, the advantages of cleaning and/or grading the crop are discussed, along with the cleaning processes used. Some of the machinery used on the farm clean and grade the grain or seed simultaneously, while others either only clean or grade. The equipment considered in the book for these purposes include a winnower (**Fig.3**), a sieve cleaner, a pneumatic separator or aspirator, an indented cylinder, a gravity separator, a belt separator, a string grain sorter, a specific gravity separator, a sack cleaner and a roller grader. The operating principles of the various types of cleaners and graders are also discussed, along with equipment for chemical dressing or dusting the seed, which is usually carried out as a combined operation.

Fig.3 A prototype bicycle operated winnowing machine under test

### Cutting and Chopping

Beef and dairy cattle and other types of livestock like sheep, goat or pigs eat vegetative matter like grass, hay, maize or other crops grown for forage and convert them into food or fiber in such a way that they are suitable for human consumption or use, for example meat, milk and wool. The feed provided to the cattle is best converted into human food if it is cut or chopped into a suitable size, instead of feeding it in bulk. Equipment that can so prepare the crop directly in the field are called forage harvesters, as discussed in an earlier chapter ; the second type of equipment, called a silage cutter (**Fig.4**) or a silo filler are discussed in this chapter. These include the hand chopper and the hand or power operated silage cutter, the latter rsing either a cylinder type or a flywheel type cutting head. A recently developed crop shredder is also considered for preparing the forage crop.

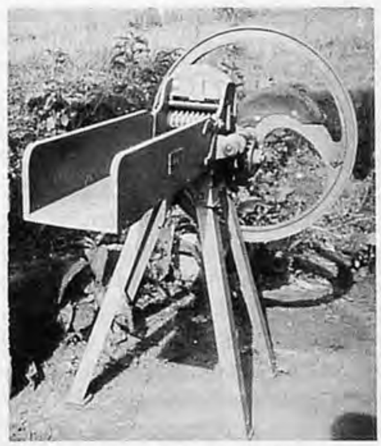


Fig.4 A hand operated silage cutter showing feeding trough and toothed rollers

### Grinding and Crushing

In processing a crop for consumption as either human food or animal feed, it is generally necessary to reduce their size ; this may be done by either grinding or crushing. The ground material is also usually graded by sieving, as different sizes of material are used for feeding various farm animals. As the power required to grind increases with the fineness of the final product, grinding is carried out only to the extent necessary. The equipment used are a buhr-stone mill (**Fig.5**) or a plate mill, a roller crushing mill, a jaw crusher, a hammer mill, a cake breaker or a combination mill using more than one of the basic devices in the same equipment. Factors affecting the choice of a mill and a hay crushing equipment are also considered.

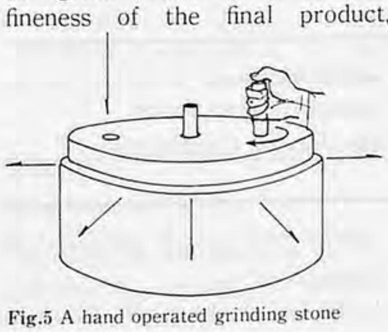


Fig.5 A hand operated grinding stone

### Mixing of Feed and Food

In preparing a balanced ration for animal feed, a number of highly concentrated food is used along with the bulk material. The three main types of mixer used on a farm are batch, semicontinuous and continuous, depending upon the quality and quantity of mixing required. The equipment considered herein are the vertical dry-feed mixer, the revolving drum mixer, the elevator-type mixer and the horizontal wet-feed mixer.

### Crop Drying

Agricultural products like grain or grass usually contain at harvest time a high level of moisture which is not safe for prolonged storage. The level of moisture is therefore reduced as soon as possible, consistent with the characteristics of the crop. A detailed consideration is made in this chapter of the important factors affecting drying, e.g. temperature, drying rate and the movement of moisture in a drying grain. The types of grain driers used are continuous-flow, platform type for bagged grain (**Fig.6**) and a ventilated silo. The

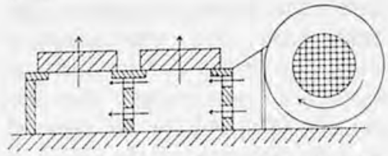


Fig.6 A platform drier for bagged grain with electrically operated heaters and fan

types of grass driers used are either low or high temperature units. Ventilation of dried material during storage is also considered important, and the relative merits of an axial flow and a centrifugal fan are discussed, along with the factors affecting the choice of a fan for drying a crop and the grain/grass drier for a given farm.

**Crop Preservation**

As plants or their fruits and seeds continue their life processes after removal from the soil or separation from the plant in which they grew, it is necessary to preserve or process the crop for later use by storage. The airflow methods used to help the material breathe during storage are natural ventilation, forced air and forced air with auxiliary heat. In processing a crop for preservation the retention of its original qualities like color, flavour, texture and nutritive value are important. The three important processing methods considered are canning, freezing and dehydration. The change in the moisture content of a crop during drying and aehydration is discussed. The drying systems considered are single-stage, multi-stage and tunnel type driers. The inter-relationship between crop variety and dehydration and the physical factors affecting drying rate and quality are considered, along with a typical flow sheet for dehydration.

**Grain Storage**

After the completion of various post-harvest processing operations, the grain or crops like fresh fruit and vegetables is ready for either consumption or secondary processing, like extraction of starch, or for disposal by sale. Storage of the grain is necessary if they are required for consumption on the farm, over a long period of time stretching up to the next harvest, or for realization of a better financial return by sale at a later date. Unless storage is carefully planned and carried out, considerable losses can occur, amounting to 25 % or more of the total crop. The various technical considerations in grain storage are discussed in this chapter, along with methods of storage, e.g. in bags, meal bins, storage bins, ventilated silo, loose bulk or outside stack.

**Crop Handling**

A large variety of material in different shapes, sizes, and states are handled during processing of crops and grains on the farm. The machinery and equipment used for this purpose includes, to name a few, conveyors, trucks, shutes, pumps, channeles, belts, scrapers, spirals, buckets ect. The objects of handling a crop on the farm are briefly considered. The methods of transport used are hand and headload, auger conveyor, belt conveyor, chain conveyor, elevator, front end loader, pumps and pneumatic blower. Their relative merits and uses are discussed in this chapter.

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**—1978 Edition —**

## Korean Agricultural Machinery Catalogue

(Korea)

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This is a volume of catalogue written in English, introducing the main products of 19 main manufacturers of agricultural machinery in Korea.

The contents enclose the color photos and main specifications of the products, and the address and telephone number of the head office and the Seoul office of the manufacturers.

Page : 30 pages. Soft covered, color-printed.

Size : 18.5 × 25.5 cm

Published by Korean Farm Machinery & Tool Industry Cooperative. (19-6, Do-Dong, Young-San Gu, Seoul, Korea).

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## Research Summary

**January 1975-August 1977**

(Thailand)

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An outstanding feature of all developing countries is the large number of people engaged in agriculture. As a consequence, overwhelming of developmental problems in these countries have an agricultural bias. In some countries within the region served by Asian Institute of Technology (AIT), the proportion may be as high as 90% of the work force.

This publication is edited by AIT which has been contributing to promotion of the agricultural engineering education in Asia, with the intention of introducing its research summary widely to the persons concerned of both inside and outside of the country.

The contents are the summaries of research papers especially on the subject which they have already acomplished or are actually studying on and after January 1975, within the field of study in "Agricultural Systems Engineering and Management" and "Agricultural, Soil & Water Engineering" which are under administration of the Division of Agricultural and Food Engineering of AIT.

If you wish to get a copy of this Summary, please take contact with AIT directly and individually, and you could receive it without any carge.

Size : 18.5 × 26.5, Page : 22 pages

Published by : Asian Institute of Technology (P. O. Box 2754, Bangkok, Thailand)

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**Engineering for Appropriate Technology**

## Farming Systems in the Lowland Humid Tropics

(Nigeria)

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This is a report for 1977 of the Agricultural Engineering Sub-Program of Crop Engineering Department of International Institute of Tropical Agriculture (P.M.B. 5320, Ibadan, Nigeria).

The contents of this report consist of 11 project as follows :

Project 1. Agrochemical applicators for small and intermediate farmer use with 'no-till' or 'minimum-tillage' mulch farming systems.

Project 2. Planters for use with 'no-till' or 'minimum-tillage' mulch farming systems.

Project 3. Development of a rolling injection planter planting through mulch.

Project 4. Development of a fertilizer applicator for use with mulch farming systems.

Project 5. Investigations in alternative low-energy rice establishment practises on hydromorphic (phreatic) soils.

Project 6. Investigations into simple methods/tools for harvesting maize.

Project 7. Development of a stripper-harvester for rice.

Project 8. Development trials of the Ransomes root crop harvester for cassava harvesting.

Project 9. Design and Development of the 'African Chief' 5 H.P. tractor.

Project 10. Evaluation trials of tractors proposed for introduction into West Africa.

Project 11. Rural Technology-Non-Ferrous casting techniques.

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**Development and Transfer of Technology Series No. 3**

## The Manufacture of Low-cost Vehicles in Developing Countries

(Austria)

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This study is based on the data available and the findings of the Expert Group Meeting. Its main purpose is to assist in promoting the manufacture and use of low-cost vehicles in developing countries. It is designed to assist government officials responsible for formulating policies on modes of transpotation in their countries and businessmen concerned with the manufacture of various types of transport vehicles. It describes the main types of low-cost vehicles, what is involved in launching their manufacture, and aspects of marketing them. It reviews recent developments in several Asian countries, with particular emphasis on India and the Philippines, where low-cost vehicles have significantly penetrated the market.

Published by United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

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## Heuristic Strategy for Scheduling Farm Operations

( Netherlands)

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Producing products on a farm needs planning. The farmer decides what to produce and how to produce it. The answers to these questions can not be given independently. To assist his decision-making a number of techniques are employed.

The aim of this study was to develop a model which :

—takes account of hourly weather data and material properties in their recorded sequence,

—uses men and machines according to their availability in regular time and overtime and according to the readiness and availability of the materials to be processed,

—takes decisions (selecting operations and length of operations) at each decision date according to an explicit strategy.

The solution of the scheduling problem contributes to the machinery selection problem by using the model for different sets of men and machines.

The book is divided into two main parts as follows :

- Scheduling operations : a heuristic strategy (Terms and subsystems, Literature, Decision values, specifications and extensions of the urgencies, Decision dates and state transformation, Simplified scheduling problems)
- Grain harvest : a case study (Weather, properties of materials and weather forecast, Materials, Men, equipment and operations, Simulation program, Experiments, Discussion)

Published by Centre for Agricultural publishing and Documentation, Wageningen, the Netherlands. ■■

# BACK ISSUES

(Vol. 9 No. 1～3, 1978)

# NewsLetter

**INTERNATIONAL FARM MECHANIZATION RESEARCH SERVICE**


c/o SHINNORIN-SHA 2-7 KANDA NISHIKI-CHO CHIYODA-KU,
TOKYO, JAPAN., TEL. 03-291-5718, 3674


Dear friends

International Farm Mechanization Research Service was established in 1968 with the pourpose of promoting efective communications and researches on agricultural mechanization especially in developing countries.

We will gladly welcome everybody to join us who want to promote free and vital communications on agricultural mechanization over many barriers like sectionalism.

Our body is really independent one supported by every member's free and active mind to make better world.

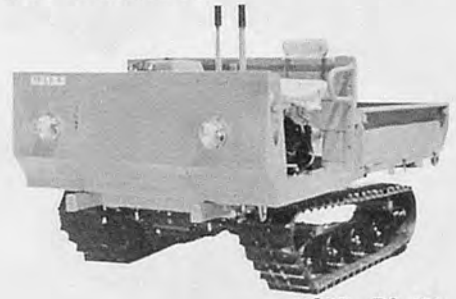
Whenever you need more informations, please write me.!

Yours Sincerely
*Yoshikuni Kishida*
Head of Directors

# FARM-PORTER

A SERIES OF OUR TRANSPORTERS ARE MOST SUITABLE FOR HAULING OVER BEACHES, SANDY OR DAMP GROUND, SLOPING ROADS, AND SNOWY SURFACES.

- FARM-PORTER runs smoothly.
  The all-rubber caterpillars beat sand, mud, and many other troublesome conditions.
  Slopes up to 40° declination present no problem, even when the FARM-PORTER is fully loaded.
- FARM-PORTER has the largest load carrying capacity in its class. 500kg (1,100 lb)
- FARM-PORTER is very well balanced.
  The low center of gravity (height to platform: 500m/m (1ft 8in)) and wide caterpillars provide great stability.
- FARM-PORTER has multiple gear transmissions.
  (Three forward and 1 reverse)
- FARM-PORTER Pivots on one spot.
  It turns freely and compactly by switching off one of the two clutches to fully disengage one track on which it revolves.



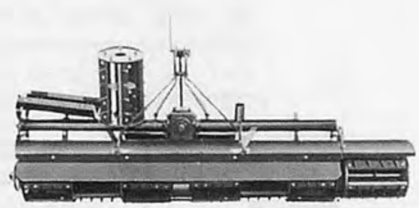
MODEL P6 121

MODEL P9 600

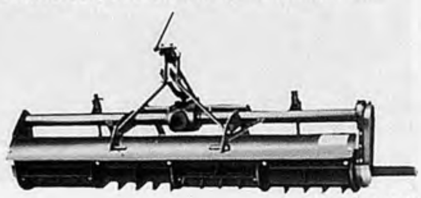
**SHIROISHI KOKI CO.,LTD.** 4-chome, Kita Hondori Shiroishi-ku, Sapporo-city, Hokkaido, Japan Telephone: 011-861-7131

# Niplo DRIVE HARROW

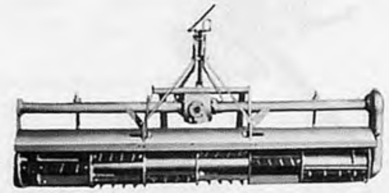
- Because of the unique shape of blades, puddling and clod breaking can be completely performed at a time.
- The unique levelling equipment and soll moving system make fields even and smooth.
- It is light enough to keep balance with a tractor even In muddy paddies and easy to handle.
- It requires less power and can harrow widely. It is economical.
- Blades can be easily replaced.
- Model HZ-240LA can be folded both sides by 45 centimeters.
- It produces a fine upper layer and rough lower layer, the ideal soll condition for rice planting.
  The universal joint is a standard attachment.



Model HZ-240LA



Model HY-201



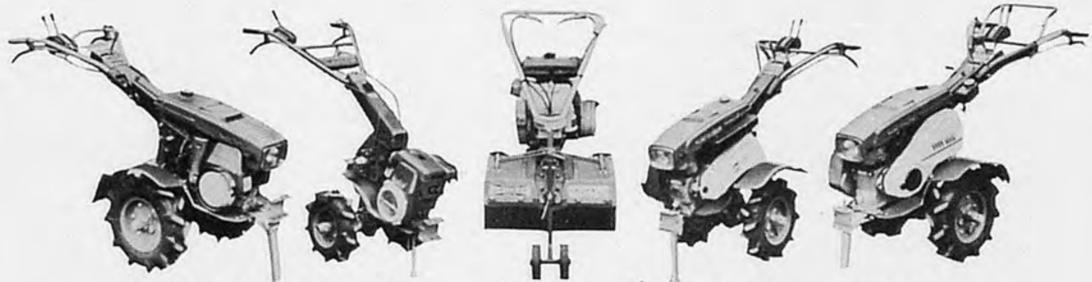
Model HD-20A

| Models | Dimensions (L×W×H) | Weight | Harrowing Width | PS of Tractor required | Rotor R.P.M (PTO540) | 3point linkage | Working Speed | Capacity |
|---|---|---|---|---|---|---|---|---|
| HY—201 | 618×2137×952mm | 199kg | 2000mm | 15—25ps | 211rpm | Cat. 0.1 | 2.0–3.0km/h | 30～50a/h |
| HD—20A | 950×2400×1160mm | 280kg | 2300mm | 25—35ps | 248rpm | Cat. 1 | 2.5–5.0km/h | 40～90a/h |
| HZ—240LA | 950×3220×950mm | 450kg | 3200mm | above35ps | 275rpm | Cat. 1.2 | 2.5–5.0km/h | 50～130a/h |

**MATSUYAMA PLOW MFG. CO.,LTD.**

2949, Shiokawa, Maruko-machi, Nagano-ken, 386-01 Japan

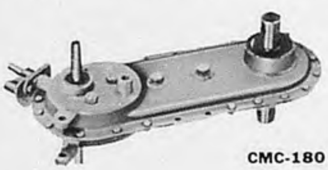
# CULTURE ALL OVER THE WORLD



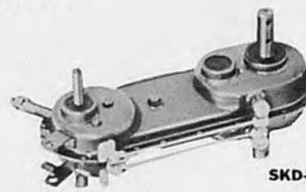
**PM-350** **DMC-II** **MRV3** **SKD-II** **HMD-250**

*We are provided other Japanese manufecturerd with the transmission only.*
*We believe you can find the satisfaction with MAMETORA AGRICULTURAL MACHINERY.*
*We have not only the tiller but also the transmission under oder.*

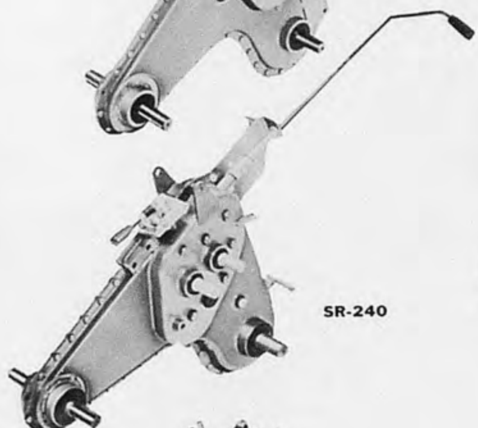
**MRV3**



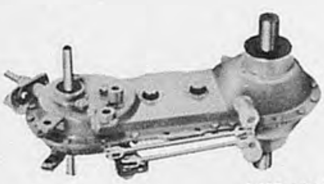
**CMC-180**



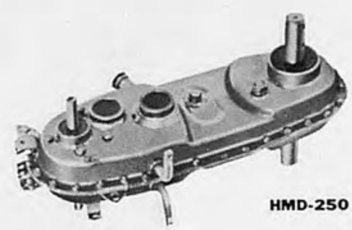
**SKD-II**



**SR-240**

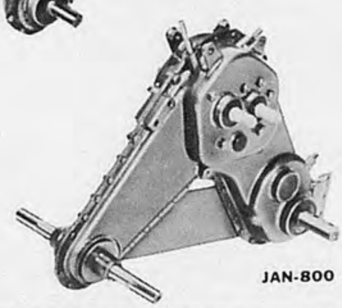


**DMC-180**



**HMD-250**

**UK-13**



**JAN-800**

**PM-350**

| Model | | MC-80 | MCF-130K | CMC-180 | DMC-180 | DMC-II | SKD-18 | SKD-II | SKD-III | HMD-250 | PM-350 | UK-13 | MH-750 | MT-40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Applications (PS) | | 1·8~2·5 | 2·0~3·5 | 3·0~4·5 | 3·0~4·5 | 3·0~4·5 | 3·0~4·5 | 4·5~6·0 | 4·5~6·0 | 5·0~7·0 | 6·0~8·0 | 3·0~4·5 | 3·0~4·5 | 3·0~4·5 |
| Shifiting Stages | | F1 | F1, R1 | F2, R1 | F2, R1 | F3, R1 | F2, R1 | F2, R1 | F3, R1 | F4, R2 | F6, R2 | F2, R1 | F1, R2 | F1, R2 |
| Sidecluch | | — | — | — | — | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ with Lock |
| Gear Ratios | | $F_1$=1:21·71 | $F_1$=1:18·16 | $F_1$=1:25·41 | $F_1$=1:25·41 | $F_1$=1:41·31 | $F_1$=1:21·21 | $F_1$=1:31·06 | $F_1$=1:66·07 | $F_1$=1:70·03 | $F_1$=1:53·97 | $F_1$=1:32·13 | $F_1$=1:25·54 | $F_1$=1:37·62 |
| | | | $R_1$=1:27·24 | $F_2$=1:15·38 | $F_2$=1:15·38 | $F_2$=1:19·40 | $F_2$=1:10·28 | $F_2$=1:11·34 | $F_2$=1:18·96 | $F_2$=1:38·73 | $F_2$=1:37·41 | $F_2$=1:16·92 | $R_2$=1:29·37 | $R_1$=1:32·83 |
| | | | | $R_1$=1:35·58 | $R_1$=1:35·58 | $F_3$=1: 9·35 | $R_1$=1:21·33 | $F_1$=1:44·52 | $F_3$=1:11·43 | $F_3$=1:15·81 | $F_3$=1:18·50 | $R_1$=1:32·77 | $R_1$=1:20·22 | $R_2$=1:10·69 |
| | | | | | | $R_1$=1:49·91 | | | $R_1$=1:81·09 | $F_4$=1: 8·74 | $F_4$=1:19·42 | | | |
| | | | | | | | | | | $R_1$ 1:105·04 | $F_5$=1:13·47 | | | |
| | | | | | | | | | | $R_2$ 1:23·71 | $F_6$=1: 6·66 | | | |
| | | | | | | | | | | : | $R_1$=1:66·67 | | | |
| | | | | | | | | | | | $R_2$=1:24·0 | | | |
| Dimensions | A | 170 | 170 | 170 | 170 | 202 | 192 | 192 | 224 | 234 | 243·5 | 192 | 192 | 192 |
| | B | 434 | 434 | 434 | 435·5 | 532 | 492 | 492 | 545 | 578·5 | 603 3 | 467 | 467 | 467 |
| | C | 289·5 | 289·5 | 289·5 | 289·5 | 344·7 | 336·75 | 336·75 | 336·75 | 319·7 | 402·5 | 409·9 | 287 | 287 |
| | D | 15 | 15 | 15 | 15 | 16 | 16 | 17 | 19 | 19 | 19 | 16 | 16 | 16 |
| | E | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 34·5 | 34·5 | 31 | 31 | 31 |