International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VI, NO. 1, SPRING 1975

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

TEST YOURSELF

1. You are farming wet paddy. The weather has turned and it's time to prepare the ground for planting. The problem is, you have more land than you can till by yourself. In order to get the paddy planted you need:

   A. Many friends and relatives.
   B. A Kubota K120 Power Tiller.
   C. To sell some of your land.

2. You have some good land which has been used to grow coconuts. You want to convert the land for use in cultivating sugar. For this you need more water than is available on the land itself. You have a good source of water but it is some distance from the land you wish to use. In order to get the water from your source to the land you need:

   A. 3,000 water buffalo.
   B. Rain every day.
   C. Kubota pumps and pipes.

3. You are raising grapes in vineyards in the Saône Valley of France. You have acquired some new land which is perfect for grapes. However, the land is not level but rolling and, in places, almost mountainous. You want to till the land but do not have the manpower to use on the slopes and most farm machinery is too heavy and bulky to use on the steep terrain. You need:

A. A Kubota L175 Tractor.
B. Trained mountain goats.
C. Dynamite to level the terrain.

4. It is late September. Your rice fields are bursting with one of your best crops. You had intended to spend the next two weeks harvesting, binding, and separating the rice prior to refining. Now you hear that a sudden typhoon is about to strike before you will have a chance to complete the harvest. You need:

A. Weather insurance to cover your losses.
B. A Kubota HX 700 Combine.
C. Neighbors and their children to help harvest.

ANSWERS

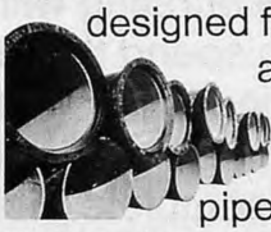
1. B

KUBOTA K120 Power Tiller

The K120 is one of three Kubota Power Tillers designed for wet paddy use. Along with the K75 and the K700, the K120 is compact, efficient and loaded with extra features. Tough, lightweight construction means the K120 can go anywhere to perform any job.

2. C

KUBOTA Pumps and Pipes



Quick to install, easy starting, compact and powerful, designed for easy maintenance, Kubota Pumps are the answer to any irrigation problem. And Kubota technology has made it a world leader in the production of pipes. From PVC piping to super strong ductile iron, Kubota has the pipe to solve the problem.

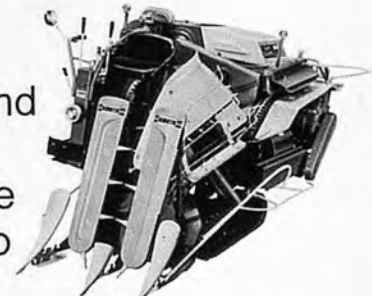
3. A

KUBOTA L175 Tractor

Along with the L225 and the B6000, the L175 is the perfect tractor for jobs requiring heavy power from a medium sized design. Perfect grow power for jobs ranging from vast wheat fields or mountain vineyards to wet paddy. With ten speeds (two reverse) and a four speed Power Take Off you have extra flexibility.

4. B

KUBOTA HX Combine



The Kubota series of combines and cutters and binders provides the easy, efficient way to harvest your crop. Special design features, like sturdy rubber crawlers on the HX Combine, to prevent getting stuck in a muddy paddy, ensure that your work will get done quickly and profitably.

MORE ANSWERS

Kubota has the answers to the preceding test and to any test you may face in the agricultural area. As an example of other Kubota solutions to agricultural problems consider:

Irrigation systems

As a leading manufacturer of both water transportation equipment and agricultural equipment it is only natural that Kubota has been responsible for the evolution of complete irrigation systems. Starting with the pumps and engines necessary to draw, carry and drain water for irrigation and drainage, Kubota carries water in high quality PVC or asbestos-cement pipe. Once at the destination water is pumped through a range of Kubota sprinklers, all offering high quality, maintenance free performance.

Agricultural Machinery

In addition to the machinery shown above Kubota has a complete line of agricultural machinery ready to help you with any agricultural task. Power tillers, cultivators, tractors, combines, cutters and binders, are only part of the Kubota picture. There are also mechanized fertilizers and seeders, weeders, threshers and hullers and mowers. Finally, to protect your crops, Kubota markets a wide variety of sprayers and dusters ranging from large high-speed sprayers to small hand dusters.

Diesel Engines

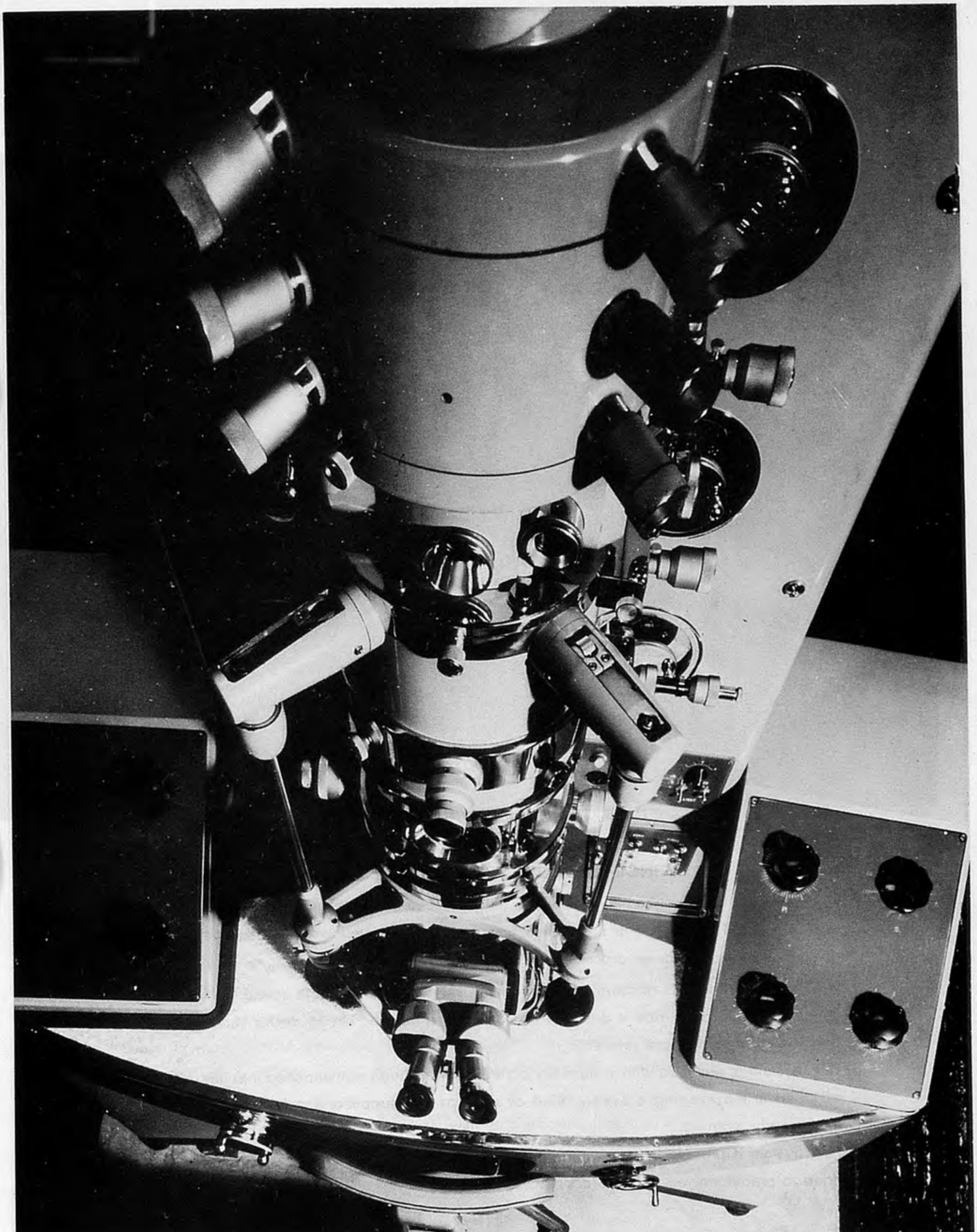
Sometimes the power to make Kubota machinery functional must serve more than one purpose in order to be truly useful and efficient. Kubota has the answer to the problem of safe, low-cost, convenient power. The Kubota range of diesel engines gives you portable power wherever you need it. Power generation for pumping, driving machines, irrigation, providing light. Whatever your power needs in agriculture there is a Kubota diesel engine to get the power to you.

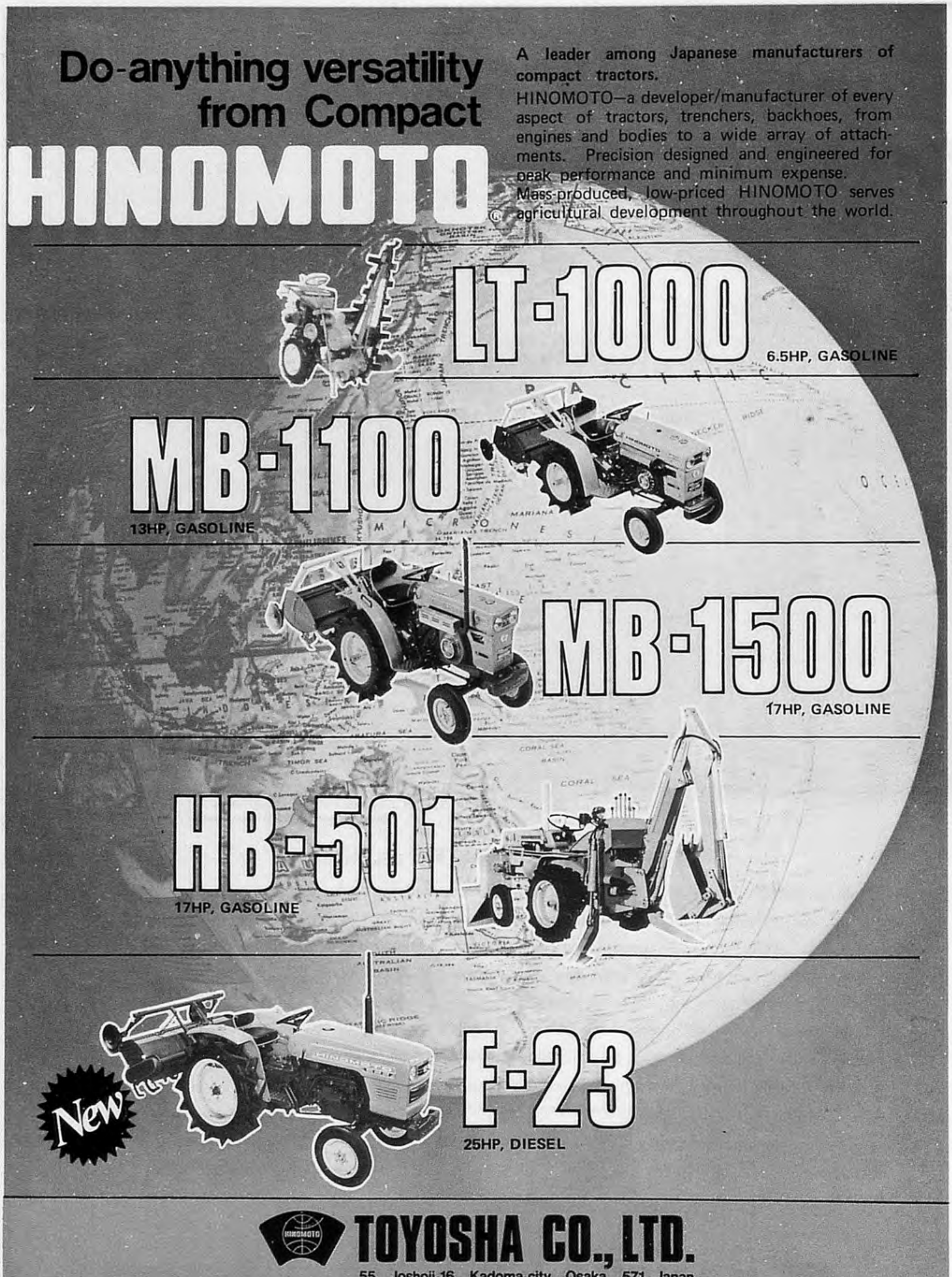
TEST KUBOTA

The tests of agricultural productivity are not all black and white. But they are all difficult. And there is evidence that the tests and problems of food production are growing every day. In order to answer the questions that arise, to solve the problems that face us, we will have to turn to higher technology for agricultural production.

Kubota has been hard at work for several generations, trying to meet the challenges in this area. Efficient use of land, irrigation of non-arable land, greater crop yields, mechanized systems of production; these are all demanded by the future. Kubota is working today to meet those demands.

The time when hand implements and human or animal power could suffice, is fast coming to an end. Labor saving, production expanding machinery, operating efficiently and profitably, is part of the new age of agriculture. As you enter this new age, think of Kubota. Whether your needs be in diesel engines to provide generator power, tractors for the steepest hills or the muddiest paddies, tillers, combines, cutters, binders, excavators, pumps, pipes or valves, Kubota can help you enter the new age of agriculture. Whatever the test, whatever the challenge, Kubota has answers.

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AMA

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VOL. VI, NO. 1, SPRING 1975

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Preface

AMA was planned to be published in the Winter of 1974 titled the 1974 Winter issue (Vol.V, No. 2). Since, however, it became out-of-date, we have published this as the 1975 Spring issue (Vol.Vl, No. 1).

The first purpose of this issue is to concentrate on the problems of after-service and supply of spare parts, which have recently become a problem when machanizing agricultural techniques in developing countries. However, as we could not get suitable articles on that, we have edited topics concerning general agricultural machinization. On the problem of after-service, various different problems are caused by the attitude of technique of manufacturers in developed countries and marketing of importers, and the state of parts production and development of agricultural machinery in developing countries. This is very important problem. We hope we will get suitable articles on this theme and publish them on future AMA.

During the passed several years, the agricultural machinery in the world has modernized. The prices of agricultural products have rapidly increased. The food crisis is assuming a more serious aspect. In this age, especially, high-populated Asian countries are in a serious situation with the future food problem. We believe that now co-operation is required to solve these problems among persons who are engaged in agricultural machanization, such as users, dealers, manufacturers, scholars and so on.

We will do our best to come to understand each other's problems, requirements and desires.

Chief Editor
Yoshikuni Kishida

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AGRICULTURAL MECHANIZATION IN ASIA

Vol. VI, No.1, Spring, 1975

Adoption of the Drum Thresher for New Rice Varieties in ASIA

by
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The high-yielding varieties of rice are being introduced in many Asian countries. Different countries experience various adoption problems that may be climatic, agronomic, diseases, insect and rodent pests or managerial in nature. Some of these factors, such as the climate, are quite uncontrollable by the rice producers. Others, however, such as management, the producer can modify. Harvesting and handling methods and techniques can be controlled to some extent at least within the economic constraints by the producers.

One of the persistant characteristics of the higher-yielding varieties of rice is its tendency to shatter (separation of the paddy kernels from the rice stalk) more easily than the old indigenous varieties. This characteristic is quite advantageous for the threshing operation ; however, significant shattering losses can and do occur before harvesting and afterwards during any handling of the paddy rice in the stalk form. Shattering losses from higher-yielding varieties can be greatly detrimental in offsetting the possible higher yields obtained. Rice lost during cutting, handling, preserving or marketing, and thus is not eventually consumed benefits no one. In fact, the producer has invested expensive inputs of seed, water, fertilizer, insecticides and labor into its production and received no returns.

Field shattering losses have been estimated in the range of 5, 10 and even 20 percent of the total yield under various conditions. Producer yields have not been near as high as the research stations obtained. A study of agricultural mechanization in South Korea concluded that high shattering losses account for a significant part of the lower net yields (Exotech, 1972).

Preharvest shattering losses may be minimized by timely harvest, and post-harvest losses may be nearly eliminated by proper handling. A basic principle is that the sooner after harvest and the nearer to the point of harvest that stalk paddy is threshed, the less the shattering losses. This paper discusses and presents an analysis of shattering loss minimization through the use of a foot-pedal, drum-type thresher in the field near the point of harvest. Inasmuch as immediate field threshing of timely harvested rice presents a grain paddy drying problem, selected drying methods and techniques will also be discussed.

Harvesting and Handling Methods

In Japan, the single rice crop that is possible under the prevailing climatic conditions is harvested mainly by machine···either self-propelled combines or binders. By 1973, there were some 200,000 combines in use on some 3,000,000 hectares of paddy rice (Kishida, 1974). Prior to 1960, and mechanical harvesting, most of the rice in Japan was dried in the field by hanging the bundled stalk paddy over bamboo poles. The foot-pedal drum thresher was first developed in Japan for threshing in the field or at the building site. The post-1960 era of binder and combine harvesting presented a drying problem, and by 1973 over two million small mechanical farm dryers were introduced.

In Korea, only one rice crop is possible, but in the southern provinces a second crop of winter barley can be grown if planted immediately following rice harvest. In spite of this double-cropping potential, the traditional harvesting practice includes considerable field drying of stalk paddy after cutting. Field drying was no doubt started because of the normally good autumn weather during the harvest period. Traditionally, the rice stalks are cut by hand laid out on the stubble. After a couple days, the stalk paddy is bunched and tied with a few rice straws. In some cases, the paddy bundles are set up vertically in rows for further drying. The bundled paddy is then eventually moved from the field to a central point for threshing. With the old indigenous varieties and when double cropping was not considered, the field drying was logical. Today, with the new higher-yielding varieties with the inherent high shattering characteristic, along with the double-cropping potential, field drying and excessive handling is not feasible. Present off-field threshing techniques in Korea vary from hand beating, the hand comb separator, foot-pedal drum thresher, powered versions of drum threshers to the semi-automatic self-feed Japanese thresher.

In the Philippine Islands, the tropical climate makes multiple cropping of rice possible where irrigation water is available throughout the year. Hand cutting of the stalk paddy near the ground is traditionally practiced. The stalk paddy is them moved to a threshing site as soon as possible to clear the land for preparation of another crop. Threshing is done by various means of treading and hand beating to powered drum-type threshers. The grain paddy is then still high in moisture content after threshing so must be dried immediately. One of the harvest seasons occurs during the rainy months of October and November ; thus, the traditional sun drying practice is not feasible. The use of imported mechanical heated-air convection-type dryers has been the only alternative. They are, however, large, very expensive, sophisticated in control, and require a high level of operational expertise. They are only suited if at all for centralized drying and processing plant operations. The small and fragmented farms, the many different varieties planted, the lack of feeder roads and transportation means and still the low price paid to the producer for his wet grain paddy all work against the possible success of the centralized dryers. The small one-ton, box-type batch dryer would seem to have a place for operation at the village-level farmers' organization or cooperative.

In Indonesia, as in the Philippines, new rice varieties and multiple cropping are being adopted as water is made available for year-around production. The traditional harvesting practice still prevails, however, of cutting each rice stalk about 20 cm below the head and then binding into small bundles. The small bundles are transported to the building site for some sun drying, stacking and eventual processing or marketing. The Indonesian farmers have not traditionally done any paddy threshing other than that which was hand pounded for family consumption. The short-stalk paddy is thus marketed in the bundled form. Also, much of today's home-consumed rice is carried to the small processor in the bundle form where it is threshed, possibly sun dried some more, hulled, polished and then returned to the family home. Great shattering losses occur during this excessive handling procedure, particularly with today's new higher-yielding varieties. Today, some of the bundled stalk paddy is transported in gunny bags instead of completely exposed as in the past. Farm and field threshing, possibly with a drum-type pedal thresher, seems to be applicable.

The Harvesting Need

A means of threshing the stalk paddy as near to the point of cutting and as soon after cutting should be introduced in order to minimize shattering losses. The cost of such a threshing unit must be acceptable. This means without mechanical power in most developing Asian countries. The threshing unit must be light for ease of movement from field to field with manpower even in quite highly terraced fields. Some field drainage control will, however, be necessary for movement and operation of the thresher on stable soil. Some means must be available to handle the wet, uncleaned grain paddy after threshing.

The lightly constructed and simply designed foot-pedal drum thresher meets these prerequisites for field threshing of freshly cut stalk paddy. The simplicity of the machine makes it readily reproduced locally from indigenous materials at a nominal cost to farmers. The operation and maintenance of the thresher is simple. The drum thresher should still be classified as a labor intensive type of mechanization; however, the use of it does allow for more timely threshing for minimization of losses, and relieves some of the hand labor associated with hand beating or treading of paddy.

The minimization of shattering losses with the new highr-yielding varieties will justify its introduction in countries even though there is no need for labor efficiency. In Korea and some other countries, the drum thresher would also provide for rapid clearance of the field for multiple cropping. In Indonesia, its introduction would require a more drastic change in harvesting techniques, but should still be considered. First the stalk paddy must be cut with a longer stem (40 to 50 cm) attached to the head so that the stalks may be held by hand against the rotating drum of the thresher. Possibly the stalk paddy should be cut near the ground so that most all of the straw can be removed from the field with just one cutting. Also, for the farmer to do the threshing will be quite new in Indonesia. This added operation will, however, provide the farmer with the opportunity to sell some more of his or hired labor by upgrading his product for marketing. Once threshed, the farmer can also clean and sun dry a considerable amount of the grain paddy to upgrade it further for marketing. Forced air, mechanical batch drying will probably become available at the village rice mill or primary cooperative level. Hopefully, the farmer would also receive some of the increased market returns from the properly dried, high head yield (minimum cracked rice) quality product.

Taiwan has used the foot-pedal drum thresher nearly exclusively for the past two or three decades; thus, there is a precedent for its application. The last few years, a number of the drum threshers are being adapted with small stationary engines for displacement of labor. The mechanical power does not increase appreciably the capacity of the threshing unit. A cost-benefit analysis is included for both in this paper.

Drum Thresher Operation and Cost-Benefit

The operational cost of a machine can be calculated with the equation

$$C = \frac{F}{N} + V$$

Where C = total cost per hour of operation
F = annual fixed cost
N = working hours per year
V = variable cost per hour

The reliability of the resulting total costs is as good as the total life estimates and cost values used for analysis. With the rapidly changing costs of materials, manufactured goods and labor, it is difficult for any given answer to be highly representative of general conditions. The annual fixed cost or depreciation of the threshing machine is based upon the purchase price and estimated length of life. For analysis purposes, 1972 prices and operational experience in Taiwan will be used.

Purchase Price = \$24.00
Length of Life = 12 years
Salvage Value = None
Annual Depreciation
= \$2.00/year
Interest on Investment
= 12%/year
Interest/Year = 24.00x0.12
= \$1.44/Year
Miscellaneous Costs @ 1%
= \$0.24/Year
Repair and Maintenance @ 2%
= \$0.48/Year
Total Fixed Annual Cost
= 2.00 + 1.44 + 0.24 + 0.48
= \$4.16/Year

The variable cost of operating the drum thresher by foot pedal is minimal. By assuming 1.5% of the purchase price is needed per day of operation for such things as lubricants, the variable cost would be \$0.36 per day or \$0.045 per hour for eight-hour days.

As for hours of operation per year, an estimate is assumed from Taiwan experience. In 1966, there were 194,247 drum threshers in Taiwan and a total rice crop (two crops) of 788,635 hectares. If it is assumed that 95% of the rice was threshed by drum threshers, which is conservative for 1966, each drum thresher was used for 749,203/194,247 = 3.86 hectares. It is further estimated that the time required for threshing one hectare of paddy rice varies from 8 to 12 hours, depending on the number of people in the threshing team. If 10 hours is assumed in order to provide an average, the annual hourly use = 3.86x10 = 38.6 hours. With the previous equation then :

$$C = \frac{F}{N} + V = \frac{4.16}{38.6} + .045$$

$$C = 0.108 + .045 = \$\,.153/\text{Hour}$$

In Taiwan, the contract cost for leasing a drum thresher was about \$0.20 per hour, so some advantage of ownership is indicated. However, the average farm size in Taiwan was in 1966 still about one hectare, and drum threshers were being used on nearly four hectares. If total double cropping of rice is assumed on the one hectare, this still means each drum thresher was used on at least two farms. The drum threshers were then either leased to neighboring farmers, they exchanged work or, possibly, jointly owned the threshers.

Figure 1 has been prepared and included to compare the cost per hour with hours of use per year for the drum thresher. The lower curve plots the equation $C = 4.16/N + .045$. Based on these cost data, then it is shown that with the lease cost at \$.20 per hour, the break-even point of use would be only 27 hours per year. Also then the cost per hour for utilization of about 39 hours per year is shown to be about \$0.15 per hour, similar to the previous calculations. An enterprising individual that would want to do more contract work with a thresher could possibly double the annual use in hours up to about 70, thereby reduce the hourly cost to \$0.10, and still charge the \$0.20

going fee.

The powered drum thresher would, of course, have a higher operational cost. A similar cost analysis is included here with the following assumptions:

Fixed Costs

- 3-hp engine at $75.00
- Engine Life=7.0years
- Salvage Value=$5.00
- Depreciation of Engine =$10.00/year
- Interest=75×1/2×12 =$4.50/year
- Miscellaneous Fixed Costs @ 1%=$0.75/year
- Repair and Maintenance @ 8%=$6.00/year
- Total Fixed Costs =$21.25/year

Variable Costs

- Fuel @ 0.6 gal/hour @ $.66/gal=$.40/hour
- Miscellaneous Costs =$.10/hour
- Total Variable=$0.50/hour

Thus, $C=\frac{F}{N}+V=\frac{21.25}{N}+0.50$

When this cost for the engine is added to that for the thresher, the combined

$$C=\frac{(4.16+21.25)}{N}+(.045+0.50)$$

$$C=\frac{25.41}{N.}+0.545$$

This curve was also plotted and included in **Figure 1.** It is immediately evident that the hourly cost for the engine-powered drum thresher is much higher than for the foot-powered one. If the cost is to be held at or below $1.00 per hour for the engine-powered thresher, then it must be used nearly 60 hours per year. The engine might be used for some other farm tasks of pumping, spraying, sawing, winnowing, ropemaking or whatever to lower its fixed cost some. In any case, the extra cost of engine power can only be offset through the saving of labor. Where labor is abundant, this would be quite an unadvisable move to make. Only if and when labor is not available at an equivalent price should the engine power be considered.

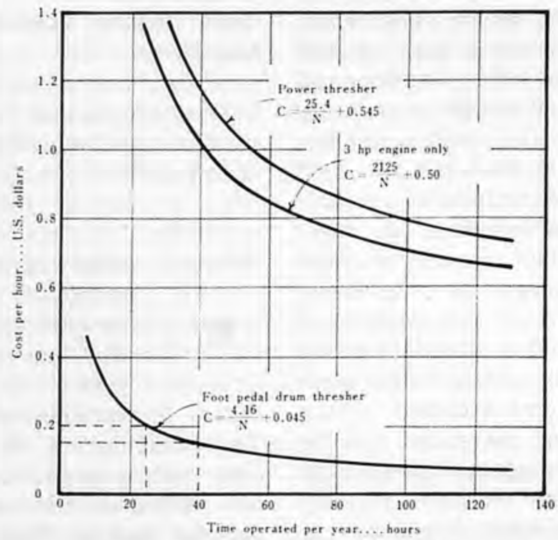

Fig. 1. Average hourly cost of drum thresher based upon total hours of use per year and 1972 prices in TAIWAN

Foot-Pedal Drum Thresher Operation

The foot-pedal drum thresher is designed and constructed wide enough for operation by two persons. The same two persons do not, however, operate it continuously. This would be impossible. Continuous pedaling by the same person can only be sustained for 15 to 20 minutes. A team approach is thus necessary. A four-person team is minimum. The individuals pick up a small bunch of stalk paddy from the point where it was cut in the field and rotate on the thresher two at a time, each pedaling until they thresh their own bunch. The rotating of the two pedaling must alternate so that the momentum of the drum may be maintained by one individual at all times. This team effort spreads the pedaling task amongst four or more individuals, thus making it a tolerable labor intensive operation.

In a few cases, and . Comilla, Bangladesh, is a case in point, there have been unsuccessful attempts to introduce the foot-- pedal drum thresher. In these unsuccessful attempts of introduction, a critical factor has often been overlooked in the adaption and adoption process. This is the fact that one person cannot operate the drum thresher continuously for any period of time without becoming exhusted. The fatal tendency in introducing the drum thresher is to make it narrower for one-man operation to save manufacturing costs. Farmers will invariably not accept the one-man drum thresher as an improved, viable or efficient way of threshing. Even if one man could pedal the drum thresher for some time, it would take two or three other people under field conditions where the paddy is not stacked to carry the stalk paddy to him. All of them might as well be sharing the pedaling load on a continuous intenrmittent basis.

If a four-man crew is used for the foot-pedal drum thresher, plus another to care for the grain paddy, a total of about 50 man hours will be required to thresh a hectare of paddy. This may be a saving of 50 or 100 percent in threshing labor, as compared to other non-mechanical-powered means of threshing; however, the critical reason for introduction (possibly only in a labor surplus area) is to accomplish the threshing in the field as near to the point of paddy cutting as possible to minimize or practically eliminate shattering losses. Timeliness of clearing the field for multiple cropping would be a secondary justification.

Paddy Drying

There is the inevitable problem of wet grain paddy with the drum threshing procedure when the paddy is harvested at 20% moisture content or above as it must be and when threshed in the field immediately as it must be. The grain paddy from the drum thresher contains a lot of foreign material, so cleaning takes extra time and labor. The wet grain paddy must be dried immediately to prevent spoilage and sun drying can be a problem during the wet season.

Mechanical means of grain drying are just now being introduced in limited numbers in some of the developing countries of Asia. Drying technology is fairly complex, and most of the grain dryers introduced to date have been large, sophisticated, expensive machines. As with the premature introduction of big tractors in some less-developed areas of the world, in many cases the dryers were soon inoperative due to a lack of maintenance repair parts or operational skill.

As with threshing, the drying problem should be approached with intermediate technology if possible. The simplest and thus least expensive is the batch-type (about one ton) with forced low temperature (about 30 to 40°C) drying air. The dryer can in most countries be constructed of indigenous materials with the exception of the engine to drive the fan and possibly the fan and oil-fired air heater. A batch-type paddy dryer of this type has been developed in the Philippines (Depadva 1973) and is being introduced through their farmers' organizations.

The batch dryer may take from 5 to 20 hours to dry a batch (one ton) of paddy, depending on such factors as: the amount of water removed from the paddy, climatic conditions, heated-air temperature, and rate of air flow through the grain. The unit thus had a capacity of one or two tons per day. At this rate, the drying time required per average farmer would only be 2 or 3 days (one hectare at 4 tons yield and two one-ton batches per day). An individual farmer would not normally invest in this simplest of dryers unless he planned on doing considerable custom contract work. The drying does, however, seem to be adaptable at the village level in the primary cooperative or farmers' organization. If each harvesting season extended over a month, each dryer could dry between 30 and 50 tons per season.

The slow-type, low air temperature batch dryer has numerous advantages over large centralized plants, such as: better distribution at the farmer level to minimize distance and stress of transporting wet rice, simple to operate, maintenance and operational costs are low, and low drying air temperature causes minimum kernel crackage.

REFERENCES

Exotech Systems, Inc., 1972. Farm Mechanization Program for Korea. Washington, D. C., August.

Rice Production Manual, 1970. University of the Philippines with the International Rice Research Institute. Revised edition.

De Padua, Dante B., 1973. A Rice Dryer for the Farm. University of the Philippines, Department of Agr. Engineering, Tech. Bull. No. 1.

Farm Machinery Yearbook, 1973. Farm Machinery Industrial Research Corp. Kanda-Nishikicho, Chiyodaku, Tokyo 101, Japan.

Taiwan Agricultural Yearbook, 1967 Edition. Department of Agriculture and Forestry, Taiwan.

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Engineering Research at M.A.R.D.I. for Malaysia's Farming Future

by Ray Wijewardene
F.A.O. Advisor,
Agr. Engineering Research
M.A.R.D.I.* Malaysia

Twenty five years after tractors were introduced to Malaysian farming, mainly imported from Europe; and with some fifteen years experience of power tillers from Japan, the question is now appropriately posed "Whither mechanization for Malaysia's farming?".

The experience of the past merits analysis, for the bearing it has on policy for the future.

Dependency

Perhaps the most serious aspect of mechanization trends hither to has been the dependency it implies on imported machinery for so basic and strategic a national commodity as food. Tractors and power tillers marketed in Malaysia retail at about 150 to 200 per cent of the price which a farmer in the country of manufacture would pay; after freight and local sales margins are added for exporter, importer, distributor, dealer, saleman, etc. A high price to pay for a product designed and developed for totally different farming conditions!. The bitter lesson of dependency has already been learned in the field of fuel and fertiliser!. Revaluation in Japan caused prices for power-tillers and agro-chemicals to jump a further 25%! The lesson of dependency is most bitter when it affects the means for producing food.

Nor can any of the tractors or power-tillers 'Popularised' in Malaysia be manufactured here; and a commitment to 'assembly' would further aggravate the predicament as is now well realised in the local automobile industry! It is also no more feasible to envisage the return of the buffalo to the rural tillage scene. There are too few, and a breeding program would take decades. The lesson is clear. Such mechanization as is to be developed in Malaysia-and an appropriate mechanization is essential if food targets will be met, -must realistically be capable of manufacture within the country. The agricultural engineer in Malaysia needs now to rise above his earlier role at the far end of a foreign tractor-manufacturers marketing campaign, with his scope limited to 'testing' and 'adapting'.

Dependency on imported technology and machinery leaves Malaysian agriculture open to the pressures of embargoes or supply of machinery and spares under unfavourable political climates and disadvantageous trading conditions or terms.

Understandably, tractor manufacturers have looked to 'export' markets to offset increasing domestic production costs. The British tractor industry now needs to export several times its domestic requirements to cover the overheads of mass-production! Expectations, however, that farming in developing Asia would shape along the European pattern have not materialised. Farms have become smaller, not bigger, with the pressures of population on land. This has been the pattern even in highly developed Japan, which now reports both man-power and mechanical-power inputs per acre higher than anywhere else in the world.

If anything has been clear, it is that the mechanization pattern of Japanese agriculture is as inappropriate to Malaysia-and indeed to most of South and South East Asia, -as the mechanization pattern of Europe and the West!.

Role of the farmer

It is appropriate, also to look coldly at the energy involvement of various Europe-Western and Far-Eastern systems of mechanization. Both these systems are known to consume, now, some four to five times the energy to produce the same quantity of grain as was produced some thirty years ago. Perhaps this indulgence of a cheap energy resource was justified then. Whether it is justified at the present cost of fuel and in the S.E. Asian context is very debatable!.

Alarming, in a more subtle way, has been the relegation of the farmer by the current trend of mechanization, to the role of an observer of someone else - the contract tractor operator-doing his farming for him! Misguidedly justified with distorted economics

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A "pedestrian-tractor", designed by the author, here developed further while at "M.A.R.D.I." to include a very simple "power-steering" and "implement-lift". Note the sharp corners achieved and absence of unplowed bits at the corner of the field. The art of good plowing for weed-control is returning after a decade of mis-guide obeisance to the "rotary-filler" for primary fillage:

this attitude often reaches further towards replacement of the farmer by the combine harvester and mechanized transplanter.

Design of machines for Malaysian agriculture needs totally to involve the farmer and to resolve his problems; not to displace him nor his way of life. That the drudgery and risk of traditional agriculture has not attracted the youth to the land is understandable. The glamour of the city; 'the streets of London paved with gold'; but above all, the security of a steady job and steady income. If farming is to attract the young man back to the land, these attractions must apply even more to the skill and prestige of agriculture. Continuity of gainful employment throughout the year instead of peaks of intense activity followed by lulls of the fallow. A ture understanding of the farmers life is essential if the engineer - as also any other agricultural scientist - is really to resolve his problems.

Input sophistication

The tendency for agricultural research throughout Asia to take place in disciplinary isolation has sadly resulted in a degree of sophistication further and further away from the farmers ability to apply. The soilscientist pours on fertiliser; the entomologist more irsecticide; the engineer more power. Results on the research station are indeed impressive! But so also the gap between these and the yields achieved by the farmer under the conditions to which he is constrained; economic, social, and physical.

Now all research needs to become more farmer applicable with inputs realistically guaged to local availability. More than lip service is needed to the principle of interdisciplinary research. For the engineer this means a through integration of his endeavours with those of the breeder the agronomist, the soil scientist; into an integrated resolution of the farmers problems; of his productivity; the productivity of the land he farms.

The farm factory analogy

Blessed with a year round growing season the Malaysian farm bears appropriate analogy with a factory. Farm land fallow is like a factory idle; its capital unproductive, its workers in difficulties. The success of the plantation industry has been its year--round productivity and continuous employment apportunities. Where arable farming is concerned the concept of seasonal or annual cropping has happily given way to double cropping; yet this still leaves the farm idle for a third of the year. The trend, therefor, to treble - if not multiple-cropping-and the consequenting year round gainful employment of the farmer should be the prime objective. Individual crop programs and disciplines must be geared directly towards this achievement in every farming district, - each with its peculiar circumstances of terrain and rainfall. The role of the engineer in this team approach is the resolution of the 'power' problem constituting bottlenecks to productivity. Traditionally the farmers only recourse was to hire labour during these 'peaks'. However, 'mechanization' is not necessarily the most appropriate solution to the problem. Many endeavours to mechanize each manual operation on the Asian farm these past few decades have proven very wrong, and to involve considerable capital commitment for relatively little savings. Mechanized threshing machines still required that the crop be manually cut, gathered, conveyed; and still cleaned and transported Imposition of the machine on to a tradidional system has proven of only marginal benefit; what is needed is an application of engineering technology and systems analysis to the achievement of the objective. In this particular case the collection of grain.

Mechanization and systems analysis

Figure 1 illustrates the peaks of (man) power demand which pertain to traditional growing of a crop of rice in Malaysia, and well illustrates the point that mechanizing of the tillage operation - where most 'mechanization' has been devoted so far - is by no means a resolution of the farmers main problem. Rather has it been applied to one stage of farming which was easier to solve with conventional imports. By far the

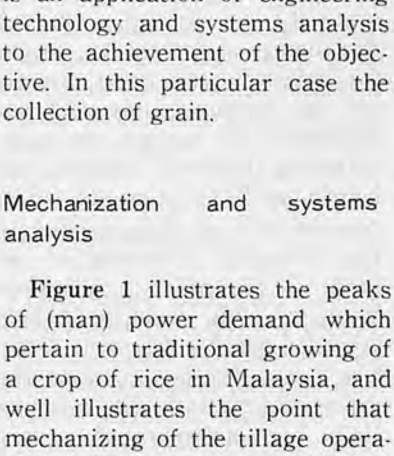

Fig.1. Illustrates the peaks of manpower involvement in manhours per ten day period on a typical three acre farm in Malaysia farmed traditionally (120-130-day crop), as well as the realistic levels to which this may change using the simple "Integrated-system" method of rice growing and a 110-120 day crop variety.

biggest 'peak demand' for labour comes during the harvesting season, in the traditional cutting, gathering, collecting, threshing and cleaning (perhaps also drying) of the paddy.

Perhaps the word 'mechanization' has been the cause of much misdirected engineering endeavour, and its unfortunate implication for straight mechanizing of manual operations.

The resolution of the power problem during harvesting is preferably achieved through developing a low-power means for collecting the grain directly off the standing crop, and not necessarily by cutting the stalk, gathering the sheaf, threshing the bundle, etc. This approach led to consideration of the principle of the 'stripper harvester;'— an early Australian development,—as this machine (which preceded the Mc Cormick 'Combine') was designed to strip the grain directly off the standing stalk. Such an approach is very feasible in the case of rice as modern varieties have already been bred to stand short and erect at time of harvest. Initial trials with the stripper harvester principle **(Fig. 2)** have proven remarkably successful and with very low consumption of power (7h.p. is quite sufficient for a 2 to 3 foot wide self propelled "stripper" for harvesting an acre of rice a day) and with only one moving part to strip the grain directly off the stalk and convey it into a bag. The straw is left standing either to be grazed or to be re-incorporated into the soil. While still in an early stage of development, the approach is evidently a very correct one. Very much more so than through 'mechanizing' each manual harvesting operation and perambulating a large machine for cutting, gathering, threshing, etc. (the combine-harvester) over the soft, delicate, tropical rice field.

Fig.2. The power tiller mounted "Stripper-harvester" strips the paddy grain off the standing crop levaving the stalks and leaves still rooted to the field. Note-use of cone wheels for low rolling resistance mobility on rice fields.

Pre-harvest systems

Just as the harvesting operations are integrated into a system for the collection of grain, likewise the traditional pre-harvest systems can be reviewed for development of simplified crop growing systems.

The objective of all the field preparation processes of transplanting, etc. is to provide as best as possible an environment for the growing of the rice crop, and rather than blindly to 'mechanize' these traditional operations an alternative 'low power' system is being developed, taking advantage also of the most modern knowledge in the agronomy and breeding of rice. It is based on the breeding of varieties of rice with the ability to emerge when sown into standing water. A method used in the colder rice growing areas of Italy and California, but hitherto a problem in the tropics. The breeding of such water-emerging varieties is now being progressed in Malaysia (M.A.R.D.I.) and Philipines (I.R.R.I.) and would enable germinated paddy to be broadcast (instead of being laboriously transplanted) into water covered, fields; the rice plant to emerge and grow while most weeds remain submerged.

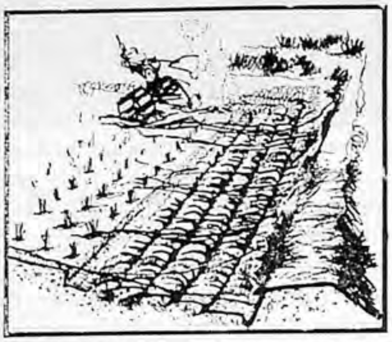

Fig.3. Redesign of simple power-tiller (for local construction, power-steering and implement lift.) used to plough the field. Turning stubble and fertilizer into the reducing layer.

To complement this intriguing approach, agricultural engineers is Malaysia are reviewing tillage practises, towards evolving 'minimum-toil' systems of land preparation. A low power (7 h. p.) simple pedestrian tractor **(Fig. 3)** has been developed for local manufacture and to perform all appropriate tillage operations—under flooded conditions if needs be—which will provide the required inversion of weeds; the incorporation of fertiliser into the reducing layer for optimum availability; the optimisation also of environment for the soil micro-organisms which are now known to convert, -in conjunction with the root systems of the paddy plant, -as much as 40 to 50 kilograms of atmospheric N per hectare!.

Complementary designs have been developed for very simple, low-cost, low-effort spraying systems for conveying to the protection of the crop the new ultra-low-volume (ULV) generation of low-pollution low-concentration insecticides and herbicides.

While this package is still being collated in research, its benefits for the farmer are illustrated also in fig. I where the lower dark shaded portion indicates the low level of power requirement which might reasonably be attained on a 3 acre (typical) malaysian rice holding through integrated systems research of disciplines working together.

Treble cropping

Treble cropping is now seen to be realistically feasible with a minimum of time lost to fallow between the harvest of one crop and the sowing of the next. The limiting factor will now be the availability of water for these subsequent crops. Traditional tillage practises are known to absorb some 500 mm. of the 1500mm. generally considered necessary in practise for growing a rice crop. (This is not only to cope with the high-evapotranspiration needs of the rice plant but also the practical losses in the irrigation systems, in channels, thru seepage, etc. A reduction in tillage time would mean a considerable reduction in water requirement. But it also enables a realistic consideration to be made of the prospects for extensive treble cropping of rice on the coastal clay soils, -and indeed this is already a practise with some enterprising farmers.

In areas where water availability is limited by nature to only one rice crop a year the growing of at least two alternative 'upland' crops such as maize or sorghum and grain legumes or sweet potatoes is becoming very feasible with simple systems being developed between the agronomist and engineer at M.A.R.D.I. These crops will be grown on ridges formed during tillage operations after the rice harvest, and enable the root zone of the crop to be raised above saturation levels even after a heavy, unexpected shower of rain. While in essence being a simplified version of the 'raised-bed' practice of the market gardener, it also enables supplementary irrigation through the intervening furrows—say perhaps once in two or three weeks ——which would go far towards optimising profitability and ensure high yields even during the traditionally dry months from February to May. A conservative estimate is that some 350,000 acres of single cropped, irrigated paddy land in Malaysia can still be producing three rich crops of food a year, two of them 'upland', with occasional supplementary furrow irrigation (Note: 935,000 acres of poddy land in Malaysia is double-cropped and 545,000 acres single-cropped. Yields average 1.4 tons per acre; about the highest in Southern and S.E. Asia).

A particular feature of the engineering designs being developed at MARDI is the facility incorporated to combine two or more manual functions into one "mechanized" one. For example, inter-tillage, hilling-up and weeding can now be performed in one operation. This principle is developed further with the agronomist for simplifying relay and inter-cropping systems of high productivity farming which would otherwise not be practical for reasons of excessive power demand and intensification of technique.

Upland irrigation

Although sprinkler irrigation has been demonstrated on Government farms, its use by the farmer is unlikely on grounds of high capital cost. Two low cost, farmer-applicable, systems are currently under evaluation for the irrigation of 'upland' crops; one being the furrow system described earlier and the other the Australian 'trickle' system. The latter appears to have potential for orchard crops on high permeability and coarse soils where water availability is very limited. Too much water would be lost getting to the root zone of each plant were surface irrigation (e.g. furrow) used on such crops planted, say, over 3 metres apart; and too much lost on the intervening soil space between trees were sprinklers to be used. The 'trickle-irrigation' system is

The same "pedestrian tractor" re-developed here for throwing up high ridges for the growing of tapioca (Manihot Utilisima). Growth is much improved, weeds controlled entirely and lifting of tubers facilitated. Special rotors were designed for ridging simultaneous with cultivator.

particularly attractive for its ease of adaptation from locally available materials, and great flexibility of application in conveying water direct to the root zone of the plants.

Machine development

The simple machinery being designed to perform the variety and wide range of functions described is intended for manufacture in Malaysia. Imported will be only the steel (sections, sheet and billets) bearings and fittings, and the engine (a light 7 h. p. kerosene engine) which together will import for less than a one-third of the M$1,200 dollar (M 2.4=U.S. 1) target retail price of the basic tractor (pedestrian). A specially simplified transmission is now under development for this tractor incorporating very innovative but technologically appropriate and advanced methods for ease of local manufacture and maintenance. Significantly, rubber will play an important part in this development!. Maintenance levels will be kept well within the capability levels of the thousands of motor cycle and scooter repair shops already available throughout the country.

It is designed for use BY the farmer, for use on rice-fields or on 'upland' crops, and to plow, cultivate, ridge, weed, seed, 'puddle', thresh, 'stripper-harvest', mow and trail (1/2 ton trailer)-—the versatile farmers powertool.

Large scale (extensive) mechanization

The 60 h.p. tractor as imported from Europe will doubtless continue in the Asian scene for several years although the damage it (with the rotary tiller) causes to the 'pan' of rice fields has already reached alarming levels. It is now known that each operation of a tractor with rotary tiller over a clay soil, saturated, rice field results in the pan being chewed into at least a further 5 to 10 m.m. Little wonder, then, that much of the rice--fields in the nothern Malaysia states of Kedah and P.W. are new becoming too 'boggy' even for the buffalo!.

On first impressions the 'negative-draft' of the rotary-tiller appeared an advantage. That it produced a good seed-bed was evident. That it also produced a favourable weed-bed and a highly erodable condition was only realized later!. A return to time proven tillage practises is now envisaged and particularly in conjunction with the new 'minimum--toilage' growing systems being developed.

A major reason for the damage caused on rice fields by the tractor has been the use of incorrect tyres. The conventional 'FIELD-MASTER' tread as developed for European farming is quite suitable for use on estates but very incorrect on rice fields for which a range of a 'RICE & CANE' tyres has already been developed in U.S.A. but never used (or even tried) in Malaysia. Experiments with these deep lugged tyres on the standard tractor have recently commenced at MARDI and have been found in extensive trials to reduce tremendously if not eliminate completely the tendency to 'bogging' now increasingly attendant upon the operation of tractors on wet rice fields.

Engineering against erosion

The training abroad of Malaysian agriculture scientists and teachers has not been without its problems in the incorrect impression there conveyed of what constitutes appropriate agricultural practises. Tillage over undulating terrain, as in Europe with 20 inches of rainfall evenly spread over the year produces very different results when adopted on the humid tropics with 80 inches falling, mostly in short sharp deluges of very high intensity. Erosion levels in the order of 20 to 40 tons of soil per acre each year are common—if not realised!. And not only on commercial estates, on which herbicides have often denuded what little surface cover is left under the heavy overhead canopy, but also on farms of government and national educational institutions!. Erosion control methods, though taught and learned in principle, are inadecuately demonstrated or applied. Erosion was not too severe when tillage and land development was limited in application to manual methods. With increasing use (or rather mis-use) of machinery, the extent of erosion becomes staggering! Apart from researching and applying correct erosion control systems for tropical conditions on its own stations, it is expected—through the Land & Water Development Department of MARDI's Agricultural Engineering Branch—to establish realistic levels of 'permissible' erosion under Malaysian conditions and under prevailing rates of regeneration of fertility; also to devise easily applicable systems for containing erosion within these limits.

Engineering in processing.

'Post Harvest-Engineering' is the term now used to describe the procedure pertaining to the handling of agricultural crops after harvest; drying, storage, and preparation for the market. Conservative estimates place post harvest losses of rice in Malaysia at around 20%, which itself is staggering in terms of national loss. Yet an endeavour to devise a scheme, say, of improved storage or drying would itself be futile unless developed in the context of the whole sequence of events from harvest to consumer. A change in drying systems is usually of insignificant value unless the procedure for handling the crop-perhaps in bulk instead of in bags—is also revised. The services of Britain's Tropical Products Institute' (Tropical Stored Products Department) were therefor accepted to assess the whole procedure of grain storage and processing for the resolution of the particular problem of how to cope with the 'off season' rice crop which is usually harvested during wet weather and would rapidly develop mould if not correctly dried and stored.

On its own, MARDI engineering has been working on the harnessing of microwave energy for the drying of agricultural crops with particular reference to paddy. This process has proved remarkably effective, quick and simple, apart from the substantial reduction in both capital and operating costs in comparison with 'tower' drying using the LSU and similar conventional grain drying systems. Drying of paddy can now realistically be accomplished in 20 minutes as against 20 hours by conventional methods. A particular innovation has been the procedure for 'air--fluidising' of the grain during the microwave drying process to remove moisture as it is exuded; to restrain rise in temperature of the paddy to levels acceptable for good milling and to convey the paddy through the microwave chamber.

Power Tiller Industry in India

by
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India

It is a well known fact that Power Tiller Indistry was originally designes and developed in Japan mainly for rice cultivation. In the early 50's this industry has rapidly grown in Japan and at one time there were as many as 50 manufacturers of Power Tillers and their peak annual production has reaches in Sixties more than 300,000/year.

India being one of the major rice growing countries and also having very large number of small to medium sized farms, Power Tiller was considered to be the most suitable and ideal machine for Indian Agriculture. Distribution of farm holdings is given in Annexure-I. The Government of India has encouraged some private parties to collaborate and manufacture these Power Tillers in the country. My Company, Krishi Engines Limited, had applies for an Industrial Licence to manulacture in the year 1964-65 and has taker up the manufacture of these Power Tillers in collaboration with M/s. Akitu Industry Co. Ltd. for Power Tillers and with M/s. Daikin Kogyo Co. Ltd. for Kerosene Engines. This Company being the very first one, has gone through a very long period of gestation. It had to not only develop various ancillary suppliers for this new industry but also to organise sales and service network in the rural belt. Besides this Company, being a small to medium sized industry, had gone through lot of financial difficulties. Therefore, the growth of this Company and also Power Tiller industry so far has been rather slow. This Company had to change the original kerosene engine to diesel engine as the availability of kerosene oil was getting more and more scarce.

Meanwhile the Government of India has permitted another five parties to collaborate and manufacture Power Tillers in the country. The list of all the conpanies is given in the Annexure-II. Most of these companies also had similar initial difficulties and so far the progress has been rather slow.

Reasons for inadequate growth of Power Tiller Industry in India :First of all this is a new concept to Indian farmer and in the absence of wide scale publicity and extension agencies, many farmers are not even aware of the existence of such a machine and its operation and usefulness to Agriculture. Added to this the

Power tiller waitting for shipment in a factory non-availability of credit in adequate measure to small and medium sized farmers is another very important reason for the slow off-take of Power Tillers by the farmer. So far comparatively low cost of bullocks and cheap agricultural labour has worked as deterrent for the popularisation of Power Tillers.

However, since last one year this situation seems to be rapidly changing. The cost of bullocks and the feed and maintenance cost and also the cost of agricultural labour is increasing. Therefore, the insterest in Power Tiller by the farmer is also increasing. With this trend, it is expected that the demand for Power Tillers added to the credit facilities being made available, is expected to increase rapidly. Also the recent legislation by the various State Governments on the limit of individual farm holding should help to boost the demand for Power Tillers in the coming years.

Versatility of Power Tiller : It is also not very much known and appreciated the Power Tiller and its usefulness to the farmer. The Power Tiller can not only be used for puddling, ploughing, cultivating and harrowing both for primary and secondary land preparations, but also it can be successfully used for transporting, pumping, spraying, threshing and several other uses of the farmer. In fact in all row crops where minimum gap is 30" and more, this is the only machine that can be operated. Particularly in the crops like Cotton, Groundnut, Banana and also Sugarcane this machine is quite suitable for intercultivation purposes. Also the economics of using the tractor for pumping and spraying and even transporting compared with Power Tiller is in favour of Power Tiller as the full HP is not utilised in the big tractors. Also in all the hilly areas the only machine that can be conveniently and successfully used is Power Tiller. Therefore, the future of Power Tiller industry should be very bright, although the growth has been rather meagre for various reasons mentioned above.

Therefore, the Power Tiller industry In India can be said to be poised to not only expand rapidly to meet its increasing demant within the country but also to export and share its know-how with other manufacturers in developing countries. In fact the experience of Indian Power Tiller Manufacturers is perhaps more relevant and useful to develop this industry in other developing and under-developed countries than from a very advanced country like Japan as their sophistication and technology is far too high.

Annexure-1 Farm power spectrum

Power source	Farm size (hectares)	Holdings (numbers/%)	Land area (hectares/%)
Bulleck pair	0—5	43,694,000 (86.6%)	64,600,000 (48.2%)
Small tractor	5—10	4,538,000 (8.9%)	30,600,000 (22.0%)
35 hp tractor	Above 10	2,294,000 (4.5%)	38,600,000 (28.9%)

Annexure-2 List of power tiller manufacturers

Name of the unit & location	Horsepower range 3—4 hp	5—7 hp	8—12 hp	Total
1. Krishi Engines Ltd. Hyderabad. (AKITU-Japan)	—	3,000	—	3,000
2. VST Tillers Tractors Ltd. Bangalore (MITSUBISHI-Japan)	—	—	5,000	5,000
3. J.K. Satoh Agricultural Machines Ltd., Kanpur (SATOH-Japan)	—	6,000	—	6,000
4. Kerala Agro-Industries Corpn. Ltd., Trivandrum (KUBOTA-Japan)	—	—	12,000	12,000
5. Indequipp Engg. Ltd. Ahmedabad (ISEKI-Japan)	—	10,000	—	10,000
6. Maharashtra Co-op. Engg. Society Ltd., Kolhapur (YANMAR-Japan)	—	—	4,000	4,000
Total:	—	19,000	21,000	40,000

Transport of agricultural products by the use of power tiller is manufactured in India

After Service Activities and New Products of David Brown Tractor

by David Brown Tractors Ltd.

The Service Parts Operation

The efficient and reliable supply and distribution of service parts to meet the requirements of users of the Company's products, is recognized at all levels as a major and fundamental service and responsibility of the David Brown Tractor organization.

The Service Parts Department was formed before the first tractors rolled off the assembly lines in 1939, and has been operating with the full support of the manufacturing organization ever since. Under the heading of "Product Services" it involves directly more than a hundred employees and distributes more than two thousand five hundred tons of components globally every year.

This output is made up from the twenty thousand stock items in the range, to satisfy upwards of fifteen thousand orders received annually from the franchise network in one hundred countries of the world.

It is calculated that there are at present three hundred thousand David Brown Tractors in operation, and Company policy is directed to ensure continuity and efficiency of the highest possible standard.

Components are held as stock items for ten years after the date that they were last incorporated in production models, but due to the progressive development policy in Design Engineering, many components are common to earlier models and in practice many modern parts can be adapted for use on earlier models. Indeed, reports are frequently received of David Brown Tractors originally supplied in the early 1940's still operating successfully.

The quality and condition of Service Parts when delivered to the customer is of the utmost importance and to eliminate the possibility of inconvenience and frustration to users, the same rigid standards of quality control are applied to all parts intended for replacement purposes as for vehicle production.

The experience gained in exporting parts to all countries of the world over the past thirty years has provided the practical background for the measures employed to ensure that materials do not suffer from damage or deterioration in transit. This is borne out by the relatively few claims made for compensation in this area and the many occasions on which we, as a company, are complimented on our packing, identification and preservation performance. Here again we have drawn on our experience and involvement with the various Government's Representative's requirements and their acknowledged high standards for ensuring utmost dependability over long storage periods.

Successful Service Parts supply operation obviously depends on dispersal of replacement parts stocks at strategic points throught out the franchise areas, and the Company encourages distributors in selective parts stockholding with regularly spaced replenishment demands based on usage rates and lead times for procurement. This is ably supported by special attention to 'Tracdown' or 'Emergency' orders which can generally be sent from the Factory within twentyfour hours of demand.

The Marketing aspects of the Service Parts operation provides easy-to-understand parts catalogues for all models, interim bulletins on changes, marketing information and statistics. When requested, stockholding recommendations are submitted in accordance with tractor population mix in any area and instructional education is available on the many aspects of parts stock control, storage and distribution.

Since it is an accepted fact that Service Parts distribution must not only support the sale of new vehicles by providing an efficient and acceptable level of customer service, but must also prove profitable to the distributor, the Marketing section of Service Parts takes a very close interest in maintaining two-way communications on such subjects as prices, margins, inventory levels and stock turnover rates, and can be called on for advice and constructive comment.

Education and Training for After Servicing

The David Brown Tractors Training Centre is situated at Meltham near Huddersfield in Yorkshire in an old baronial hall, set in a picturesque moorland setting in close proximity to the factory.

This building has been specially converted to accommodate the Product Training Centre and has a large main hall which incorporates a cinema and showroom where special displays are presented from time to time. It also has a number of class rooms for instructional purposes. In addition to class rooms wherein is given theoretical training, there are other class rooms for practical work which contain motorisedunits for example, dealing with the hydraulic system of the tractor and a full range of highly specialized equipment related to such operations as injector testing, hydraulic pump testing etc.

In addition to the presentation of service training courses, the centre also provides the facility for other Departments of the Company to undertake marketing courses and conferences, lectures and other similar operations. There is a full range of audio-visual equipment, including projectors with direct recording facilities, magnetic stripe play-back facilities etc.

The centre is in the control of a Chief Instructor, who reports directly to the Publicity Manager of the Company. Two full-time lecturers are employed, these people take basic courses, but additionally our main suppliers, for example, Messrs. C.A.V., the tyre companies, and other organizations, do provide their own senior lecturers who participate in our main classes.

The type of courses that we present are as follows:-

Comprehensive Hydraulics —5 days
Selectamatic Hydraulics —2½days
Case 970 —5 days
(subsequent to 1972/73)
Product Initiation —5 days
Product Initiation —2½days
Engine and Transmission —5 days

It is of interest to note that our worldwide travelling Service Instructors all participate for a period of 6-9 months as trainee instructors in our Service School. Prior to this they do in fact undertake an 18-24 months product training programme leading up to the final stage of entry into our schools. The object of this exercise is principly to give them


New 91hp David Brown Tractor 1412

complete familiarity with the product, and the knowledge of how it functions. By these means we can send them with confidence to any part of the world to undertake service training in either the most sophisticated of premises or out in the field.

A further qualification of our Field Instructors, is that they are in the majority bi-lingual, this is of considerable importance in dealing with the European markets and others further afield, such as the South American territories, for example.

In presenting overseas training, our Instructors, generally speaking, are operating service training courses for our Distributors who are in the main the importer and Distributor of the product in the various territories. It is however, their principle function to undertake service training courses at the premises of our Distributors.

It is one of the conditions of appointment of our Distributors handling our franchise, that each Distributor must have adequate workshop training facilities.

The service courses whice are given at our Headquarters at Meltham are fairly obviously mostly presented to our UK Distributors and Dealers. We do however each year, run a series of special courses as-circumstances dictate, for groups of visitors to the United Kingdom, coming from the 3rd World countries and these are usually Goverment sponsored. We also present refresher courses for the Service Managers of our Distributors from each of our operational territories.

The David Brown Tractor Company has always attached great importance to service training in ail aspects, firmly believing that good after-sales service ensures satisfied customers who will continue to use our products in the future.

New 91hp David Brown Tractors

Two new 91hp farm tractors, the DB 1412 and the DB 1410 models, have been added to the David Brown range and will be exhibited for the first time at the 1974 Royal Smithfield Show in London in December.

Both in horsepower and overall weight, (nearly 3½ tons without ballast) these new '14' series tractors are the largest so far to emerge from the David Brown factory at Meltham, Yorkshire. At 91 engine horsepower (DIN) they neatly bridge the gap between the 72hp DB 1212-previously the most powerful DB model-- and the American-built 101hp Case 970, which the Meltham companyMarkets in the UK on behalf of its US affiliates.

The main difference between the two new models is in the type of gearbox fitted. The 1412 has the patented Hydra-Shift semi-automatic transmission which was first introduced on the 72hp DB 1212 tractor. The 1410 model also has a 12-forward 4-reverse gearbox but with synchromesh on eight of the twelve forward gears; this is standard equipment on all other models in the current David Brown range.

Although in general appearance they closely resemble the other models in the David Brown range, the 1412 and 1410 embody several interesting design features which are new to the marque and some which are claimed to be unique. In particular they embody extra strength and bulk at all the vital points--notably engine, rear axle, linkage and drawbar.

Turbocharger

These are the first David Brown tractors to be fitted with a turbocharger. This unit enables the 4-cylinder direct injection diesel engine to produce as much as 81 pto horsepower at 2300 engine rev/min. To complement this power capability the new engine has a crankshaft of exceptionally large diameter and corresponding torsional strength. The 12in diameter clutch incorporates special thermoid plates of new design.

The engine is fitted with a new type of aircleaner with a removable paper element. A dust trap prevents heavy particles getting into the system and the paper element prevents fine dust passing through. Air entering the engine remains dry and indicator shows red when the element needs attention. The turbocharger ensures exceptionally smooth running, and the fuel consumption (on a gall/hp hour basis) is claimed to be directly comparable with that of the notably economical DB 1212 model. As on all DB tractors, an alternator is included in the basic specification.

Hydrostatic steering

A new type of hydrostatic steering is fitted as standard equipment. This incorporates a ram of equal displacement, providing equal turning ratios to right and left. The unit is located behind and parallel to the front axle-a neat arrangement which gives the unit added protection. Oil immersed disc brakes are fitted and a new arrangement of the independent brake pedals has been devised. A centre pedal is provided for use when balanced braking is required, on road work for example. Pressure on this centre pedal automatically applies equal braking to both rear wheels.

A large capacity pump gives an output of 6½ gallon/minute at 2050 engine rev/min. The combination of large pump and heavy rear axle make it unnecessary to fit a support ram for handling heavy linkage-mounted equipment.

As on all current DB tractors a 3-way valve and coupling are standard equipment. The provision of telescopic link ends makes the job of attaching and detaching heavy implements considerably easier. When a wide implement is being used the lift rods can be set in a slotted position to assist the implement to follow ground contours irrespective of tractor angle.

In the case of the 1412 an oil cooler is fitted. Located in front of the radiator this oil cooler can be brought into action whenever operational requirements require it-i.e., when exceptionally heavy work is being carried out continuously in exceptionally high temperatures. In normal UK conditions the oil coller will not be required and since it can be switched out of the circuit, the efficiency of the hydraulic system is unaffected when the oil is cold.

Transmission

Except for a slight adjustment of ratios to match the increased horsepower, the Hydra-Shift semi-automatic gearbox fitted in the 1412 tractor is similar to the unit which has proved markedly successful in the DB 1212 tractor. This unit, which gained the David Brown Tractor Company a Queen's Award to Industry for technological achievement, is a 12 forward 4 reverse gearbox which provides four clutchless on-the--move changes of forward speed in each of three pre-selected ranges. These changes, which are achieved without loss of power are applied by a lever on the instrument panel. On-the-move gear changes are also possible in appropriate conditions with the DB 1410 tractor gearbox, which is a 12 forward 4 reverse unit with synchromesh provided on eight of the forward gears.

Massive back end

The 'back end' is the area in which the 1412 and 1410 tractors differ most obviously from other DB models, giving an immediate impression of greater all-round bulk. The size of the final drives, drawbar and pick-up hitch are particularly noticeable.

The well-proven DB multi--speed PTO is fitted to these tractors enabling standard 540 PTO rev/min to be attained at no less than 24 different ground speeds, twelve of which are suitable for carrying out lighter operations at a highly-economical 1100 engine rev/min only. Alternatively, 1000 PTO rev/min can be selected for high power operations with a choice of 12 different ground speeds.

Both the new models are available with redesigned chassis ballast weights, adding nearly 1/2 ton. The David Brown Weatherframe is available in two versions: as an unclad safety frame: or with metal cladding.

With metal clad safty cab the fully ballasted weight of the tractor is approximately 5 tons. Standard wheel equipment is : 7.50-16 (front) and 16.9/14-34 (rear) tyres, all of 6-ply rating.

Availability

Both models have successfully completed extensive field trials in the UK and the USA, and the first production models have been allocated to these two markets. Quantity production will commence early in 1975, when the new models will be progressively introduced into other overseas markets.

Mechanization Technology for Tropical Agriculture

by
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Preamble

The agricultural revolution that is taking place in most developing countries calls for considerable changes in agricultural production technology. Phenomenal increases in crop yields, resulting from resent advances in seedfertilizer technology, are increasing farm income and providing possibilities for greater agricultural mechanization. Because of the limitation of power, improved animal-drawn implements can only be of marginal benefit in the developing countries. Imported power--driven equipment from the advanced countries with different agro-climatic and socioeconomic conditions has many problems that limit their applicability. Lack of appropriate machines to mechanize tropical agriculture, within the framwork of small farm holdings and low farm incomes, has seriously hampered agricultural development in tropical Asia. To mechanize tropical agriculture, a commensurate growth of the indigenous farm equipment industry is absolutely essential. Yet almost all efforts are geared towards the transfer of mechanization technologies from the industrially advanced countries without any consideration of the manufacturing capabilities of the developing countries. The development of demand-oriented farm equipment to suit local needs, manufacturing knowhow, and other factor endowments is a problem that the engineering communities must face squarely in the developing countries.

Tropical regions are characterized by low farm income, small farm holdings, and low-cost labor. Many attempts have been made to mechanize tropical agriculture with equipment from the industrialized countries. Farm equipment from the advanced countries is basically developed for conditions of either large farm holdings and high labor costs such as in the United States, or for small farm holdings and high farm incomes as in Japan. Most imported farm equipment is not well suited for the agro-economic conditions prevailing in the developing countries. Consequently, mechanization of tropical agriculture has been slow and is limited mostly to the larger farm holdings which constitute an insignificant part of the total agricultural land.

Due to the lack of modern farm equipment for individual ownership by small farmers, efforts have been made to introduce large imported equipment in the tropics through various forms of joint use. Such efforts have met with limited success mostly for the difficult operations of land preparation and harvesting. Chancellor (1970) studied the contract hire services in Malaysia and Thailand. His study indicates a rapidly increasing sales of small two-wheel power tillers in Malaysia even when large tractor hire services were economically available to the farmers. It seems that the desire to retain control of the farm production operations and the prestige of ownership favors the use of small power tillers rather than hiring tractor contract services. This arrangement provides greater flexibility to the farmer for the tiller can be used for haulage and personal transport in addition to the cultural operations.

Small—and medium-sized farm holdings of 2 to 10 hectares constitute a large segment of the arable land in the tropics. It is ironic that with all our technological advances and new farm machinery developments, this large group of Asian farmers have little access to appropriate farm equipment. If mechanization is to be successful in the tropical region, it must be introduced on the small farm and should be considered in this particular frame of reference.

Two technologies

It has been argued that a wide range of farm equipment is readily available from the industrialized countries and that the problems of tropical agricultural mechanization lies primarily in the proper selection of farm equipment. A closer analysis that such an assumption is based on operational considerations only and fails to recognize the other important aspects which have a bearing on the mechanization issue. These aspects are the economic, sociological, and cultural needs of the farmer, lack of foreign exchange to import equipment, the level of local manufacturing know how, and the compatibility of the imported technology with the resurce endowments of the country.

Two distinct agricultural mechanization thchnologies have evolved to suit different sets agricultural and socioeconomic conditions in the world. The western approach emphasizes dryland farming with large, high-powered equipment. This capital-intensive technology has evolved from a primary emphasis on replacing human labor with machines. Introduction of such a technology in the developing countries tends to create labor surpluese and is not desirable in the populated tropical Asian region. Many attempts have been made to introduce this technology in the developing world. Nearly thirty years of efforts to introduce such a technology has, however, produced rather insigi-nificant results. In India, where tractors of over 35 hp are being introduced since the end of World War II, only one percent of the total arable land is worked with such tractors today.

Mechanization in Japan has not followed the western approach. Rice is a major crop in Japan which is grown on small farm holdings under wetland conditions. The high price support for rice, coupled with the country's rapid industrial growth and a rising standard of living, has resulted in the mechanization of agriculture with relatively low-powered yet quite sophisticated farm machines. This equipment has been developed to meet the requirements of the Japanese farmer and is far too complex and uneconomic for tropical Asia. Recently introduced Japanese combine harvesters and paddy transplanters are excellent examples of functionally suited but economically unacceptable machines for the tropical regions.

Developments in the industrialized countries are further windening the gap between the capabilities of their mechanization technologies and the needs of the farmers in the developing countries. In the western countries, there is a trend towards higher-powered machines with sophisticated control systems. To some extent, developments in Japan are following a similar trend along with an ever-increasing complexity of their machines. These developments are making it increasingly difficult to introduce imported agricultural machines in the developing regions.

In addition to their complexity, farm equipment in the developed countries is designed for manufacture with capital-intensive production methods to minimize labor inputs. Production technology to manufacture such designs is not readily available in the developing countries. The design of machine is intimately related to the production process and this severely restricts the production of imported farm machinery designs in the developing countries. Unless appropriate farm machines are designed to suit the available low-volume production technology in the LDC, production of low-cost machines would not be possible and mechanization will continue to be a luxury which only the rich farmers can afford.

The selling price of imported farm equipment in the developing countries is approximately two to four times its price in the country of its origin. Furthermore, this expensive equipment must compete with low-cost local labor. Thus, the economic yardsticks on which the farm machine is originally based are no longer present in the developing countries. Most developing countries are undergoing varying degrees of balance-of-payment problems. Even a simple calculation indicates that large-scale importation of equipment to mechanize tropical agriculture is not solution because foreign exchange shortage will not permit such a possibility in most developing countries. This dilemma can be solved through the development of appropriate agricultural machines which are in line with the needs of both the farmers and the manufacturers in the developing countries.

With the introduction of new varieties, problems of drying and processing have assumed proportions. Technology for drving and processing of crops in large central plants is available from the industrialized countries. The establishment of such plants, however, requires a well developed infrastructure which is usually lacking in the tropics. The development of small, economically viable drying and processing systemts for village or farm level operations is an urgent problem in the developing countries.

The author believes that the slow pace of agricultural mechanization in the tropical regions is due to the inadequacy of the available mechanization technologies to meet the overall requirements cf the small farmers in the tropics. It seems reasonable to contend that the tropical regions must develop their own mechanization technologies to suit their agricultural, economic, social, and industrial conditions. A closer analysis reveals an urgent need for suitable equipment for almost every farm eperation in the developing countries.

New agricultural machines from IRRI

The activities of the Agricultural Engineering Department of the International Rice Research Institute are largely to providing appropriate mechanization technologies for production and processing of rice to the developing countries. This program **(Table 1)**, initiated under a USAJD research contract in 1967, has been responsible for the development of a variety of simple machines, many of which are now being commercially produced in several Asian countries. These include power tillers, seeders, threshers, dryers, pumps and grain cleaners. We propose to describe the IRRI machines and other on-going machinery development projects in a series of articles beginning with the IRRI power tiller.

Mechanization of tropical agriculture has been a difficult problem and attempts to introduce mechanization technologies from the industrialized countries have met with little success. Agriculture in the tropical Asian countries is characterized with low farm income, small farm holdings, and low labor costs. IRRI agricultural engineering efforts are based on the assumption that mechanization of agriculture in the farmers' fields and the production of agricultural machines by local industries are facets of the same problem and must be tackled simultaneously. Agricultural mechanization can succeed in the developing countries only through the development of appropriate machinery designs which meet the needs of the small farms and can also be produced with available low volume manufacturing methods. IRRI recongnizes the lack of machinery development activities in the developing countries as a major bottleneck to the mechanization of tropical agriculture. Consequently, its agricultural engineering program is primarily focused towards development of simple demand-oriented agricultural machinery designs to suit agricultural and industrial conditions in the developing countries. One of the early results of such a machinery development effort is the IRRI power tiller.

IRRI 5-7 hp power tiller

The IRRI power tiller was developed as a simple first-stage machine which farmers could use in place a pair of animals. Simplicity of operation and manufacture was the primary

Table 1. IRRI agricultural machinery development project, June 30, 1974.

	Asian manufacturers reporting										
	1	2	3	4	5	6	7	8	9	10	Total
1. No. of machines manufactured till June 30/74:											
Power tiller	3,900	11	1,234	7	457	—	—	—	—	—	5,609
Batch dryer	—	—	—	35	—	—	4	—	74	—	113
Axial flow thresher	20	—	2	8	20	60	9	9	—	—	108
Table thresher	—	—	—	—	84	—	—	—	—	—	84
Grain cleaner	—	—	—	20	—	—	—	—	—	—	20
Bellows pump	—	—	—	100	—	—	—	—	—	—	100
Multihopper seeder	—	—	—	232	—	—	—	—	—	—	232
Single-hopper seeder	—	—	—	338	—	—	—	—	—	—	338
Power weeder	—	—	—	—	—	—	—	—	—	7,500	7,500
2. Production capacity utilization (%):											
Current	85	N R*	50	95	75	70	100	N R	95	N R	
Before start of IRRI machines	70	N R	20	90	45	50	75	N R	90	N R	
Percent change	15	N R	30	5	30	20	25	N R	5	N R	
3. No. of new workers employed	399	4	90	65	42	18	12	5	45	N R	680
4. Additional capital investment (US$)	76,000	N R	120,000	10,000	8,300	1,400	12,000	1,500	3,800	N R	233,000
5. Additional capital investment per worker (US$)	199	N R	1,330	154	197	78	1,000	300	84	N R	330

N R * = Not reported by manufacturer.
US$1 = ¥6.60.
These manufacturers have received engineering drawings and technical assistance from the IRRI project. However, additional manufacturers are now producing IRRI or similar machines by indirectly acquiring the designs for which no data have been collected.
Prototype units of some IRRI machines have been fabricated by manufacturers in Indonesia, Korea, Pakistan, Sri Lanka, Thailand, and Vietnam. Commercial production has started in some of these countries. A total of 11 Asian engineers have received short-term training under this program.

Fig.1. Plowing with a moldboard plow

Fig.2. Puddling with the comb harrow attachment

Fig.3. IRRI 5-7 hp tiller with trailer

objective in the design of the tiller. This machine is being produced by eight companies in the Philippines and is sold for about half the price of comparable imported power tillers.

The tiller is manufactured from standard machine elements such as engine, bearings, chains, seals and sprockets that are readily available in most developing countries. The rest of the machine involves fabrication of simple parts from standard structural steel sections. The engine is mounted on the frame with a sliding base. The engine drives the transmission input pulley through a V-belt. A clutch slides the engine to tighten the V-belt transmitting power to the transmission. The transmission system consists of three step chain reductions in a sealed oil bath. Double-lip neoprene seals in conjunction with felt retainers on the axle provide good sealing for muddy field operations. The weight of the tiller is only 115 kg which provides good mobility in soft flooded soils. The high power-to-weight ratio provides more power for rotary type tillage.

The tiller can perform many farm operations such as plowing, puddling, cultivating and hauling. Attachments can be readily changed without the use of tools. The tiller has a high ground clearance which makes it well suited for wet land operations. In wet soils the machine can plow 0.75 to 0.8 ha per day with a moldboard plow (**Fig. 1**). It can puddle 1.0 ha per day in flooded soils with the comb harrow attachment (**Fig. 2**). With a trailer attachment (**Fig. 3**) it can transport a payload of 650 kg over fairly rough country roads. It is easy to learn to operate the tiller since only a clutch control and a throttle lever are needed for operation.

In 1973 over 3,000 tillers were sold in the Philippines and these machines have been well accepted by the Filipino farmers. Manufacture of this tiller has also started in other Asian countries such as Sri Lanka, Vietnam, Korea and Thailand. Interested organizations can obtain further information on this power tiller from:

The Agricultural Engineering Department
The International Rice Research Institute
P. O. Box, Manila
Philippines

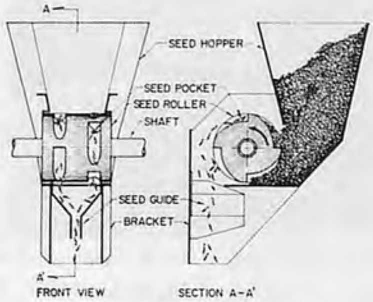
Detailed engineering drawings are also available free of cost to selected manufactures in the developing countries. Manufacturers interested in obtaining engineering drawings should submit details of their production and marketing facilities, their manufacturing plans, and other relevant information for assessment to the above address.

IRRI six-row paddy seeder

The IRRI six-row multihopper seeder (**Fig. 4**) was developed for seedings pregerminated paddy seeds in rows on puddled soils.

Transplanting is a costly time-consuming practice and is a serious bottleneck in many tropical countries. Direct seeding of rice in rows with simple seeders can be a good alternative to transplanting of paddy seedlings in the tropics. Manual broadcasting of paddy seed does not create paddy rows. Fields planted with broadcast methods cannot be weeded with available push-type weeders. The IRRI seeder can sow 35 to 50 kg of seed per hectare and one man can seed one hectare in seven hours.

Fig.4. IRRI six-row paddy seeder



Fid.5. Seed metering mechanism

Fig.6. Paddy seeder transported on levees

The IRRI seeder is lightweight and compact with a low center of gravity for easy handling. It can be built entirely of materials that are readily available in the developing countries. Intitial investment, maintenance, and operating costs are low, making the seeder ideal for small farmers.

Pregerminated seeds are picked up by seed metering rollers which have eight seed pockets (Fig. 5). The pockets drop the seeds in a furrow. The seed pockets are staggered on the rollers to minimize seed bridging. The skid is in two sections with a single wheel mounted in-between these sections. The single wheel permits transport on narrow field levees (Fig. 6). The skid allows the seeder to be pulled on the puddled soil surface with minimum "bulldozing". Three seed hoppers are attached to each skid half.

The handle height can be adjusted for the convenience of the operator and to adjust skid angle with minimized soil bulldozing and reduces pulling effort. The

Fig.7. Pregerminated paddy seed. indicates properly pregerminated steed

seeder is light enough to be easily lifted and turned at the end of the rows without disturbing the seeds already placed on the ground.

The seeds are germinated by soaking in water for 24 to 48 hours and incubating in a wet burlap sack for 24 to 36 hours. This produces pregerminated seeds with up to 5 mm long sprouts which can be planted by this machine (Fig. 7). Proper drainage of puddled field is essential since standing water in puddles can kill the pregerminated seeds (Fig. 8).

Engineering drawings are available to manufacturers intending to produce this machine commercially. Also, institutions interested in popularizing the machine can obtain additional information by writing on their official letterhead to:

Agricultural Engineering Dept.
The International Rice Research Institute
P. O. Box 933, Manila

Fig.8. Paddy seeder operated on a properly arained puddled field

Philippines

Other new machines

Another interesting example of appropriate product development in the Southeast Asian region is the case of the motorized lowlift pump (Fig. 9). This pump was developed by a farmer-mechanic in Vietnam. The first model was tested in December 1963 and by mid-1966, 600 pumps were sold. By mid-1967, the manufacturer was selling 200 pumps monthly. In less than four years after the development of the pump, nearly 43 percent of the farmers in the village owned such a pump (Sansom, 1969). Various versions of this lowlift pump are now manufactured in Vietnam, Thailand, and the Philippines.

A fourth interesting example is that of the Thai Heng Long Company, Ltd. in Thailand, which is producing high-speed aircooled engines in Chachiengsao, a predominantly rural area of Thailand. The owner of the company is a highly innovative individual and he has adapted the engine design by incorporating ideas from many popular makes of imported engines. He then set about to develop simple produc-

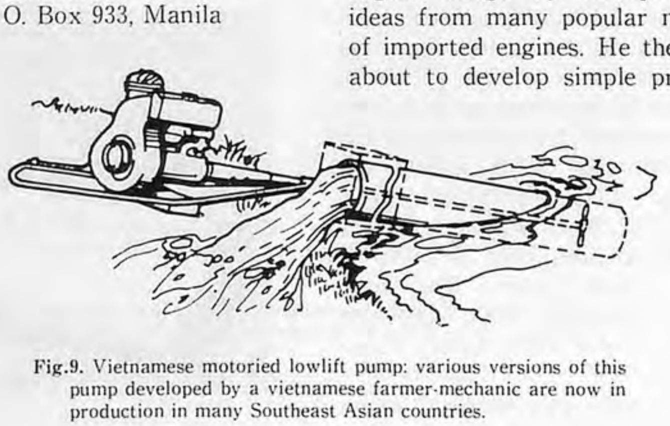


Fig.9. Vietnamese motoried lowlift pump: various versions of this pump developed by a vietnamese farmer-mechanic are now in production in many Southeast Asian countries.

Table 2. Some agricultural mechanization indicators for 11 rice-producing countries in Asia.

Country	Arable land per holding (ha)	Agricultural working population/ha	Horsepower per hectare				Hp per agricultural worker	Labor hours for rice cultivation/ha	Net domestic agricultural production US$	
			Human	Animal	Mechanical	Total			per person	per hectare
Ceylon	1.59	1.20	0.120	0.148	0.110	0.378	0.009	N.A.	293	352
Taiwan	1.11	1.95	0.195	0.164	0.164	0.505	0.074	1300	349	696
India	2.62	0.90	0.90	0.204	0.008	0.249	0.009	1000	148	133
Iran	6.17	0.37	0.37	0.048	0.154	0.292	0.418	N.A.	417	154
Japan	1.06	2.16	0.216	0.120	2.664	3.00	1.231	1400	626	1350
Korea	0.90	1.96	0.196	0.236	0.003	0.435	0.0013	830	244	477
Nepal	1.22	2.49	0.249	0.480	0.004	0.733	0.0016	N.A.	99	236
Pakistan	2.37	1.09	0.109	0.288	0.013	0.410	0.012	N.A.	154	169
Philippines	3.66	0.71	0.071	0.104	0.023	0.198	0.030	800	242	186
Thailand	3.64	1.10	0.110	0.184	0.054	0.348	0.050	N.A.	102	112
Vietnam	1.57	2.10	0.210	0.244	0.023	0.477	0.004	N.A.	203	421

Source: APO Expert Group Meeting on Agricultural Mechanization, APO Project SYP/III/67, Tokyo, October 1968, Vol. II.

tion equipment for labor-intensive manufacture. This company now produces 1,500 engines a month in the 10-, 15- and 20-hp size, with very simple, non-automatic production machines and has started to export the engines to neighboring Southeast Asian countries. This is an outstanding example where a highly complex machine is produced by simple production methods without any technical collaboration with manufacturers from the industrialized countries. In addition to these examples, one comes across many interesting caces of low-volume production of machine tools, diesel engines, pumps, and other machines in India and Pakistan.

These examples clearly indicate that economies of scale do not necessarily apply as effectively in the low-cost labor economies and should not be used blindly as an argument against local production in the developing countries. These examples prove that economic production of fairly complex machines is possible in the developing countries provided the product and production process are suitably adapted for low-volume production.

Many economists have understandably pointed to the dangers of displacing farm labor with machines. Unfortunately, such analyses are based on the amount of labor that would be normally displaced by the introduction of large, high-powered agricultural machines. If appropriate mechanization technologies with small, individually owned farm equipment are considered, the outcome would not necessarily be so unfavorable. In addition, if the production of farm equipment is in the country, employment generated in the production, marketing, and servicing functions can be substantial. The case of Japan is of interest here for it has the most mechanized agriculture in the world (3 hp/ha). Yet among 11 Asian countries (**Table. 2**),it one of the highest labor input in rice production.

There is little doubt in my mind that the socioeconomic implications of agricultural mechanization will necessitate indigenous production of relatively simple, small, powered farm equipment in the developing countries. In order to maximize employment generation, it would be further necessary to produce such farm equipment in the small- and medium-scale industrial sectors through low-volume, labor-intensive production methods.

An indigenous industry

Agricultural mechanization and local production of farm equipment are so closely related that it is unrealistic to look at one and ignore the other. Yet, most national and international efforts are concerned primarily with the introduction of imported farm machines rather than the development of appropriate indigenous mechanization technologies. The establishment of a strong farm equipment industry is a prerequisite for agricultural mechanization. The availability of appropriate farm machinery designs will play a significant part in the establishment of a viable farm equipment industry.

The limited new machinery developments that have occurred in the developing countries have been due to the efforts of local mechanics and entrepreneurs who have no formal engineering training on the development of new equipment. The academically trained engineering community in the developing countries has failed to provide the much needed leadership in the product development field. Yet opportunities for the development of appropriate machines that would be compatible with local manufacturing technology are immense in the region. It is unfortunate that the public sector engineering institutions are concerned more with research for knowledge rather than commercial type R&D activities. Machinery development is an important link between engineering research in the laboratories and agricultural mechanization in the farmers' fields. Yet it receives little attention in the developing countries. Since the farm equipment industry is not in a position to support R&D, publicly supported research institutions must focus their at-

Fig.13. IRRI power grain cleaner

Fig.10. IRRI 8-14 hp tiller

Fig.11. IRRI power row weeder

tention on this activity rather than engineering research.

IRRI machinery development program

In 1967, the Agricultural Engineering Department of the International Rice Research Institute started a program in the Philippines to develop low-cost small, power-operated machines for manufacture in Asia. Under this program, the Indtitute has developed a broad range of farm

Fig.14. IRRI oscillating grain cleaner

equipment (**Figs. 10~16**), many of which are now manufactured in the region (**Table 1**). Engineering drawings and other technical assistance is provided under this program to interested manufacturers in the developing countries. In a relatively short period of a few years, the program has achieved a high degree of commercial acceptance and is rapidly producing practical results in the farmers' fields. The Institute is now in the process of developing an intensive industrial extension program that will introduce the IRRI designs to manufacturers in most tropical countries where rice is a major crop.

RECERENCES

Fig.15. IRRI batch dryer with kerosene burner

1. Agricultural Productivity Organization. 1967. Proceedings of an expert group meeting on agricultural mechanization, Tokyo, Japan.
2. Chancellor, W. 1970. A survey of tractor contractor operations in Thailand and Malaysia. The Agricultural Development Council, New York.
3. Sansom, R. L. 1969. The motor pump: a case study of innovation and development. Oxford Economic Papers (New Series). Vol. 21. No. 1.

Fig.16. IRRI bellows pump

Fig.12. IRRI axial flow thresher

The Role of Professional Societies in Development of Agricultural Machinery Manufacture in Asia and The Far East

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Preface
(by the UNIDO Secretariat)

The "Green Revolution" has highlighted the complex inter-relationship between agriculture and industry. A significant portion of the activities of UNIDO is directed towards the development of industries related to agriculture. Agricultural machinery and implements are one of the major industrial inputs for agriculture, and UNIDO is assistind the developing countries in the local manufacture of suitable machinery and implements which are designed to suit the local crop pattern and soil conditions and which are within the purchasing power of the rural population. In addition, emphasis is placed to integrate the agricultural machinery manufacturing facilities with the facilities of the engineering industries in general, and that of metal working industries in particular.

Based upon the UNIDO activities in the countries of Asia and the Far East, UNIDO has commissioned the five following technical papers as background documents for further activities in this region as well as for the countries of other regions of Africa and Latin America. (reference: project No. 1.01.07, para 68, ID/B/97 part II., 25 February 1972).

(a) The Role of Design, Development, Adaptation and Testing in Manufacture of Agricultural Machinery and Implements
(b) The Role of Effective Repair and Maintenance in the Agricultural Machinery and Implements Field
(c) Encouraging Manufacture of Improved Grain Storage and Transport Facilities
(d) The Role of Manufacturers' Organization and Development Organizations in Promoting Manufacture of Agricultural Machinery and Implements
(e) The Role of Professional Societies and Organizations in The National or Regional Development of Agricultural Machinery and Implements Manufacture.

This paper is one of the series of the five technical papers mentioned above. The five documents highlight the inter-relationship among various activities in the agricultural machinery area (design, development; maintenance, repair; storage, transport; manufacturers' organizations, professional agricultural engineering societies) oriented towards integrated development of this important sector, which is an industrial input contributing to the "Green Revolution". It is to be pointed out that these technical papers are with reference to the problem in Asia and Far Eastern countries, but the same may serve as a valuable background literature for the development of this industrial sector in other regions of Africa, Middle East and Latin America.

Introduction

Local manufacture of agricultural tools and implements has been an age-old practice. Agricultural machinery and the manufacturing techniques are, however, changing. The modern agricultural machinery industry is quite young and in many developing countries the industry has, perhaps, been in its first decade. Professional societies can play an important role in further development of this young industry and in putting it on a sound footing.

The agricultural machinery industry will make significant progress in the decade of the seventies. It will be a key industry in many countries in the region providing great employment opportunities. A lot of capital will be invested in this industry. In India alone, the value of farmers' current annual requirements in a few important farm equipment inputs is estimated at $800 million. UNIDO's efforts will be amply rewarded if this paper inspires member countries in the region and assists them in organizing professional societies for development of this 'growth' potential industry.

Contribution of the modern agricultural machinery industry to the 'green revolution' is well recognized. Mechanization of farm operations improves productivity. Timeliness and accuracy of operations are more important to the high yielding crop varieties. A better farm operation performed faster improves cropping intensity. Taking away the drudgery from farm chores and a dawn-to-dusk working day improves the farmer's health and his standard of living through higher income and reduced costs of operation.

On the other hand, the industry has its critics and problems. It is sometimes said that mechanization will increase unemployment, depress wages and create wider disparity in rural incomes. So far, actual experience has been otherwise. In Punjab, a State in India, where there has been some acceleration in the pace of farm mechanization, wages have increased, labour availability has become more difficult and one cannot help feel the overall prosperity and improvement in the standard of living of the people. There is motivation for acquiring better skills.

Important problems of the industry underline the need for proper assessment of demand, development of markets, availability of finance, proper logistics—infra—structure and services, availability of raw materials and components, improved production techniques and economics of scale of production, research and development to suit local conditions, reasonable financial returns and economic pricing. Many problems are common to agricultural machinery manufacturers. United, these problems can be tackled better and, perhaps, more promptly; hence, the need for one or more common platforms where all concerned interests are adequately represented.

The scope of activities

The functions of a professional society will vary according to its membership and constitution, but stress has to be on its utility to the members. Its main objective is to guide the healthy and sustained growth of the industry. Its success lies in sincere and continued efforts to solve common problems faced by the members; here are some common ones which are important for the development of the industry.

Assessment of demand

An important starting point is a proper assessment of demand for major inputs. Projections of demand can cover the foreseeable future. Figures of demand should be arrived at after careful analysis of all factors which influence the demand. For example, for working out demand for farm tractors, items requiring study include cultivated area under 'large' holdings, area under irrigation, command area per tractor unit, tractor population and its growth, pace of mechanization, equipment costs and capital requirements, cost benefit ratio, identification of important crops and areas and availability of labour and wage rates.

Break-up of equipment demand can be worked out for different regions within the country and also in terms of different specifications and sizes. Accessories, matching equipment, components and replacement parts also require to be considered. Technological forecasting will greatly assist long range planning.

Development of markets

Countries in the region are exposed to modern agricultural machinery. Markets have to be developed to generate a demand. Implements have to be demonstrated and their cost benefit ratio justified for local conditions. Sales promotion efforts are required to be undertaken jointly by the industry.

The rural market is separate and distinct. Separate, because of the farmer's remote location, off-the-highway in a difficult-to-reach village. Distinct because of his literacy level, seasonal requirements and buying habits. Development of rural markets is slow and expensive. Much data is required through market research and surveys to develop the profile of the rural buyer, identify the peculiarities of the market, utilize effective media for communications and influence the farmer.

Most of the countries in the region are predominantly agricultural. A majority of the population lives in rural areas and is engaged in agriculture. Many industries are agro-based; either the industries cater to the needs of agriculture as suppliers of farm inputs or are concerned with farm output through its processing. Development of rural markets will open up a vast potential for business not only for agricultural machinery or other inputs, but also for a wide range of consumer items with the farmer emerging as an important buyer. We, therefore, need not underestimate the importance of developing rural markets as it is significant for the nation as a whole.

Finance

Finance is so vital for development of the industry. The industry has to ensure timely availability of sufficient funds for its products from factory to farm. Requirements of finance by the manufacturer, the marketing net-work (distributor, wholesaler, stockist, dealer, retailer) and the farmer have to be met.

Procedure for grant of loans should be simple, prompt, practicable and able to meet the needs of a vast number of borrowers. The cost of financing adds to the input price and should be kept at a reasonable level. Grant of loans should be business-like and based on feasibility studies, in particular ability of the borrower to earn and repay. Finance is required not only for machine tools and raw material, but also for working capital. The size of industry /business, in many cases, may be small and financing policies should suit such small-scale operations. National laws should encourage sales on hire-purchase basis.

Financing institutions can assist in organizing financing consultancy and technical services such as developing specifications, reliable sources of supplies, purchase of quality equipment and obtaining prompt and efficient after-sales-services. It may be necessary for the financing agencies to set up technical calls to service loans. Professional societies can effectively liaise with financing institutions on common problems of the industry. If the aggregate finance available is not sufficient to meet requirements, the societies can assist in determing priorities.

Production

In many countries, some items of raw materials, ancillaries and machine tools are in short supply. In many developing countries, for example, medium carbon steel is not available as the industry requires it. The situation on the high carbon steel is more difficult. Ancillary items, where availability is difficult, include pistons, rings and liners, thin walled bearings and fuel injection components. A professional organization can analyse the problem in all its aspects, discuss with the ancillary industry and attempt a solution not only for the industry's own requirements for original equipment application but also for the replacement parts market.

Quality of production is most important for agricultural machinery as,

(a) it has to stand rough and tough use (and perhaps abuse),
(b) the farmer's location makes it difficult to get prompt repairs/replacement in case of failure/defect, and
(c) accuracy and timeliness are critical for farm operations. A farmer can lose an entire crop if a pump-set goes out of order when irrigation is most needed.

Many manufacturers of agricultural machinery operate smallscale enterprises. Their problems are lack of know-how on efficient production, marketing and financing techniques. Small-scale entrepreneurs need guidance in fields such as the selection of machine tools and production equipment, production tools and gauges, jigs and fixtures, measuring and inspection instruments, heat treatment and production process, quality control and packaging.

Standardization of components can greatly help. Many countries now have national standards institutions like the Indian Standards Institution and professional organizations can co-operate with them in development of standards and quality marking achemes to the industry's advantage.

The economies of scale of production have an important bearing on the cost of an implement. Project reports and feasibility studies should be prepared with a view to establishing an economic production level. The scale of operation should suit the product and the market. Tractor manufacture on a small scale can result in high product costs. In the U.K., a tractor plant has an annual production capacity of 100,000 units as against 10,000 units in India. Licensing of too many units and over-licensing of the industry for manufacture of an item does no good either to the industry or to the farmer. The licensed production capacity in the country should bear some logical relationship to the annual demand for the product and its possible export.

Product cost is more important in a market where the buyer's purchasing power is not high and is subject to seasonal fluctuations caused by drought and the vagaries of monsoons. The manufacturer has to examine each item and keep costs at a reasonable level. In many cases, bought out items amount to 70 to 80% of the costs of the product. Vender development and efficient procurement require greater attention. Though on one hand economic product pricing is to be arrived at, on the other hand, the industry has to ensure a reasonable profit margin and return on its investments.

Research and development are essential for proper growth of the industry. Even when equipment is manufactured under collaboration with established and reputed international companies, items require to be adapted to local operating conditions and available raw materials and skills. R&D is a continuous service and is a good investment. A professional organization can liaise with research institutions and academies and sponsor research projects.

In the field of agricultural machinery, countries in the region have some important requirements of their own; these include economically priced equipment for land levelling, paddy cultivation (puddling, transplanting and harvesting), sowing (and planting), harvesting (wheat, cotton, sugarcane, groundnuts and potatoes) and post-harvest technology.

Most of modern farm equipment is being designed in highly developed countries. Is it too soshisticated for the developing countries? Is there a need for two categories of equipment like tractors and combines?—one deluxe large size version for the developed countries and the other popular, simple, small and economical version to suit operating conditions in the developing countries. The operators in the region have a low literacy level and are not mechanical minded; repair facilities are naither located nearby nor are they prompt, climatic conditions include hot summer and pouring rains in the monsoons.

Laws, rules and regulations

Every country has its laws, orders, rules and regulations to govern the industry. Most of these regulations are to protect the industry and the consumer and to collect revenue for the government. It is important that the industry is associated with the framing and implementation of the regulations.

Sometimes, some regulations create hardships and the industry is required to seek clarifications and redress and / or submit representations for review of the situation. While levying taxes (such as sales tax) and imposing customs and excise duties and octroi, its impact on the cost to the end-user should be taken into sccount. Hardships created should be promptly and sympathetically looked into, without, perhaps, compromising with the objectives of the regulations.

The industry can co-operate in developing a healthy import and export policy. The policy can be periodically reviewed. Many countries encourage import substitution and establishment of an indigenous industry. This still requires import of some components, equipment and prototypes and technical collaborations. A liberal view can accelerate the development of the industry. Similarly, the industry can help in formulation of an effective export policy for the country by laying down norms, fixing targets, devising proper inspection systems and getting exports adequately financed.

Another area of activity is the registration of agricultural vehicles using public roads. Registration formalities should be simple and prompt. Fees should not penalize the farmer unnecessarily. The authorities record data on vehicles which can be made available to the industry for its use. Some items of use are the correct and full address of the owner, equipment size and specifications and equipment population and its distribution. The industry should make equipment available which is roadworthy and which complies with the country's road and highway regulations.

Fixing retail sales prices is another important aspect to be considered. Prices may be fixed on some sound basis and should allow a reasonable margin of profit for manufacturing and marketing operations.

Fixation of freight rates by carriers such as railways and rates of insurance premia by underwriters require to be pariodically reviewed by the industry. Pilferage and damage in transit has to be minimized. Packaging of the product should permit rough handling. Insurance should cover all possible risks and claims should be promptly settled. The industry should be associated with the classification of agricultural machinery and implements for fixation of priorities and rates for various purposes like despatch and insurance.

In developing countries, agricultural machinery has not received due attention from the underwriting (insurance) companies. Insurance should cover the machine, the owner, the operator and the third party. For the first year of equipment life, perhaps, there can be a package policy to cover equipment insurance from the factory to the farm. Far animal drawn equipment, insurance of both the animals (livestock) and the equipment is involved. Insurance tariffs should be at economic rates. Sale of equipment on hire purchase and institutional loans will result in more business to the underwriters. It is important to professionally underwrite the risk of default in repayments by the farmer-borrowers.

With increased use of machines on the farm, hazards will grow. Regulations will have to cover safety. Safety consciousness will have to be aroused through a mass movement. This will involve training, publication of safety material, development of safety attachments, collection of data on accidents and corrective actions. Some items requiring attention include overturning of tractors, noise levels, vibrations, hazards due to exhaust gases and dusting/apraying operations and accidents on the highways caused by alow moving agricultural vehicles. Ensuring better safety of farm operations will greatly contribute to improving productivity per worker and par hectare.

Labour

Negotiations with labour on wages, bonus and other terms and tackling some of their problems require a joint industry effort. Sometimes, labour is well organized, is quite demanding, has better bargaining power and gets government support and sympathy.

Skilled workers are not available. Training of workers for the industry is important. Productivity per worker and the efficiency level at which workers operate equire considerable improvement. Workers leave their jobs often. During sowing, harvesting seasons, many workers take off to assist their own families in agricultural operations. Some staggering of production schedules could be considered to make allowances for such mass abenteeism. There seem to be pockets where skilled workers become available. Skilled workers do not tend to dispares over a wider area and are reluctant to migrats to distant places.

Logistics

Proper logistics are necessary for development of the agricultural machinery industry. An infra-structure has to be developed and necessary supporting services organized.

Training of operators assumes great significance. Though every manufacturer does train the equipment buyer in its operation and maintenance, this is not enough. Need is for training on a mass scale. Training should embrace the manufacturer's personnel those of the marketing organization, the end-user and also wayside garages and mechanics. Unauthorized mechanics, quacks of the trade, do more damage to the product than is realized. Yet, they are quite effective counsellors to the farmer in his choice of equipment.

Training aids have to be developed. Audio-visual aids are better used. Educational films are a great help. Iraining material is required in local languages. Costs of training are high. The industry's joint efforts with the government, teaching institutions, extension agencies, voluntary organizations (e. g. CARE) and farmers' associations will greatly help in facing this herculean task. An institution like a National Institute for Training in Agro-services (NITA) can be organized on a national and regional level. Agencies like UNIDO can greatly help in establishing such facilities.

Prompt and efficient after-sales-services and genuine replacement parts should be available to the farmer. The industry must develop proper norms, good ethics of business and healthy trade practices to creats a good image. A local dealer can be the farmer's best friend and guide; a dealer in need is a dealer indeed.

Availability of fuels and lubricants is sometimes a problem. Besides adequate quantities at the time and point of use, qulity is important. Adulteration of fuels is a menace and should be curbed with deterrent punishment. It ruins the equipment, increases maintenance costs and results in more down time. Oil Companies should impart training to the user personnel and those in the industry. Lubrication charts and guides should be freely available on local equipment. A Farm Fuels Advisory Service can be organized to handle all fuel problems for farm prime-movers.

The industry can organize a bureau of information and extension. It can collect, compile and analyse data of use to the industry. It can bring out useful extension publications and a periodical as a regular medium of communication within the industry and with all others associated with the industry such as the government, the academy, the financing institutions and the farmers.

Types of professional organizations

Professional organizations can be of various types. What is important is that they serve the cause of the profession. In some countries, one good and strong professional organization may well serve the purpose while in others, more societies need to be organized. Only local conditions and organizing capabilities can determine the number and types of organizations a country should have.

Sponsored by the industry

The agricultural machinery industry can sponsor a professional organization. It can be financed by the industry. Government and other agencies too can extend financial support. The organization will serve as a clearing house of information and act on common problems of the industry. It can also provids a common platform to bring together the industry, the government, the academy, the farmer and, in fact, any other agency devoted to the cause of the agricultural machinery industry.

A good example is the:

Farm and Industrial Equipment Institute (FIEI)
410 North Michigan Avenue
Chicago, Illinois 60611, U.S.A.

There is proposal in India to organize a local set-up on this pattern (Appendix 8.2). The proposal has been supported by the Development Council for

Automobiles and Allied Industries (the tractor industry is covered by this Development Council), the Indian Society of Agricultural Engineers (ISAE), the National Commission on Agriculture and the Task Force on the Agricultural Machinery Industry.

Manufacturers' organization

The scope of the institution covered in 3.1 is much wider, where other agencies too are invited to affectively participate in the development of the industry. There can be a manufacturers' organization with the object of tackling the common problems of manufacturers on topics like availability of raw materials, taxation and levies, import and export regulations, labour and handling problems. The organization can be a member of a federation of chambers and benefit from the experience of other industries.

Some examples are:

(a) The Agricultural Engineers' Association Ltd., (AEA) 6 Buckingham Gate, London S.W.I, U.K.

(b) Japan Farm Machinery Manufacturers Association, (Nihon Nogyo-kikai kogyokai), Kikai Shinko Kaikan Building 312, Shibakoen 3-5-8, Gooh Minato-ku, Tokyo, Japan.

(c) Farm Equipment Manufacturers Association, (FEMA) 230 South Bemiston, St. Louis, Missouri 63105, U.S.A.

Trade association

A trade association can bring together the manufacturers and the dealers. Some examples are:

(a) The Society of Motor Manufacturers and Traders Ltd. (SMMT) 21-24, Grosvenor Place, London S.W.I, U.K.

(b) Agricultural Machinery and Tractor Dealers Association Ltd., (AMTDA) Penn place, Rickmansworth, Herts, U.K.

Technical society

The technical personnel can form a professional society which can render valuable service to the growth of the profession. A society like the American Society of Agricultural Engineers (ASAE) has made valuable contribution in the field of agricultural engineering, which includes disciplines like the Farm Power and Machinery, Soil and Water Conservation Engineering (including Irrigation and Drainage), Farm Structures, Rural Electrification and Processing of the Farm Produce. ASAE has actively co-operated with fraternal institutions like the Society of Automotive Engineers (SAE) in framing standards ana laying down technical specifications and guidelines. Addresses are:

(a) The American Society of Agricultural Engineers (ASAE) 2950 Niles Road, St. Joseph, Michigan 40085, U.S.A.

(b) Society of Automotive Engineers (SAE) (Farm, Construction & Industrial Equipment Division) 2 Pennsylvania Plaza, New York, N.Y.10001, U.S.A.

Some other examples are :

(a) The Institution of Agricultural Engineers (I.Agr.E) Penn Place, Rickmensworth, Merts, U.K.

(b) The Indian Society of Agricultural Engineers (ISAE) R-531 New Rajendranagar New Delhi 60, India

(c) Society of Agricultural Machinery, Japan, Nogyo-kikai Gakkai, C/o. Tokyo Daigaku, Nogaku-bu, Yayoi-cho, Hongo, Bukyo-ku, Tokyo, Japan

Dealers, users and contractors association

A professional society can be organized separately by the Dealers, the Users and the Contractors. Functions of an agricultural machinery user association can be covered by the farmers organizations like the National Farmers' Union in U.K. and Farmers Forum, India.

Some examples are:

(a) National Farm and Power Equipment Dealers Association (NFPEDA) 2340 Homoton Avenua, St. Louis, Missouri 63139, U.S.A.

(b) American Farm and Power Equipment Agents Association (AFPEAA) P.O.Box 457 York Harbor, Maine 03911, U.S.A.

(c) Farm Equipment Wholesalers Association Suite 1100, Upper Midwest Building 425 Hennepin Avenue Minneapolis, Minnesota 55401, U.S.A.

(d) National Farmers' Union (NFU) Agriculture House, Knightabridge, London, S.W.I, U.K.

(e) Bharat Krishak Samaj (Farmers' Forum, India) A-1 Nizamuddin West, New Delhi 13, India

(f) National Association of Agricultural Contractors (NAAC) 140 Bensham Lans, Thornton Heath, Surrey C.R.4790, U.K.

Sponsored by the government

Government of India have constituted Development Councils for most of the major industries. The agricultural machinery industry is covered by

The Development Council for Automobiles and Allied Industries, C/o. Directorate General of Technical Development, Udyog Bhavan, New Delhi 11, India

The Development Council brings together the Government and the industry-the large, medium and small-scale industries, the ancillary manufacturers, various Ministries and departments of the Government of India concerned with the industry (auch as the Ministry of Steel). The Council makes recommedations on problems of the industry to the Government for action. The Council is assisted in its work by various commodity panels such as the Panel for Tractors and Panel for Ancillaries. A senior government officer concerned with the industry is the Secretary of the Council and a senior executive from the industry is its Chairman. Panel convenors are neminated from among the manufacturers. Members are nominated on the Council for a period of 2 to 3 years.

Other organizations

Then, there can be other professional organizations concerned with the development of agricultural machinery manufacture. It can be in the form of an association of manufacturers of specific product line, specific area of interest (s.g. farm buildings), manufacturers from a specific asctor or profesaional organizatione concerned with productivity and management. A manufacturing company may a in a private sector, a public sector (government), a co-operative esctor (a co-operative society) or a joint sector (with public sector participation).

Some examples are:

(a)Sprinkler Irrigation Association
13975 Connecticut Avenue
Suite 310
Silver Spring
Maryland 20906, U.S.A.

(b)The association of Green Crop Driers Limited
Geneel House,
Mark Lane, London E.C.3, U.K.

(c)Maharashtra Rajya Sahakari Sakhar
Karkhana Sengh Ltd.,
28 Goa Street,
Bombay 2, India
This is an association of co-operative augar factories in the State of Maharashtra in India.

(d)National Productivity Council,
38 Golf Links,
New Delhi 3, India

(e)All India Management Association,
29 Nizamuddin East,
New Delhi 13, India

(f)The National Alliance of Young Entreprensure (NAYE)
Alliance House,
C-20/B Green Park Extension,
New Delhi 16, India.

For developing countries, it is suggested that they begin with set-ups like the Farm & Industrial Equipment Institute and the Indian Society of Agricultural Engineers.

Setting up professional organizations

A nucleus of enthusiastic and devoted members is necessary to start a professional organization. The members should be willing to put in much time and effort and to share responsibilities. The initial start is difficult. To begin with, there may be no wholetime staff, no premises; funds too may be small. Things improve as the organization grows. The rate of growth, perhaps, varies with the utility of the organization to its members, the situation in the industry and evidence of good constructive work put in by the body.

The Indian Society of Agricultural Engineers (ISAE) made a modest start. The Society got a good fillip through two committee reports it made-the 'Assessment of demand for inputs to farm mechanization' and 'Bottlenecks in the Farm Equipment Industry'. These two raports were very timely and served the Industry well. Membership grew fast. Student membership grew because of Society awards and scholarships. Members started attending annual conventions in larger numbers as it gave them an opportunity to meet professional colleagues, get to know the latest developments in the profession and share their experience with others and benefit from the experience of others. The Society's two publications are good madia of communications the Journal of the ISAE (stress is on ressarch papare and higher technical content) and the ISAE News.

Having felt the need for a professional organization and having decided to start one, consideration is to be given to various categories of membership, memorandum and articles of association.

Membership

The following are some common grades of membership:

(a)Patron: An honorary common grades of membership conferred to honour a dignitary and seek his patronage for successful functioning of the organization.

(b)Fellow: An honour conferred on attainment of a position of eminence in the profession or an outstanding contribution to the cause of the society.

(c)Honorary Member: An honour conferred on a respectable person for his interest in society's activities and whose association with the society may be of great benefit.

(d)Life member: A member who pays his subscription in a lump-sum and who is elected to the membership for his life time.

(e)Member: who fulfils the qualifications laid down for the society's main membership. Also called active member.

(f)Associate to member: A member who may not directly qualify but has interest in the seciety's activities. He may be connected with an affiliated discipline and may like to associate with the society's work.

(g)Affiliate member: Where a membership is limited to individuals, affiliate membership is offered to companise and affiliate bodies.

(h)Student members: Who is still pursuing his studies and may join the society on completion of the course of studies.

(i) Overseas member: This category is created to admit overseas members, sometimes on concessional payments because of his inability to participats fully of sometimes on a higher tariff bacause of extra expense on postage.

Mostly, members (active members) have voting rights.

Constitution

The constitution should be drawn up by those conversant with the country's laws governing societies and companies. Services of such specialists can be hired. Objectives should be clearly drawn. As an example, Appendix 8.3 contains memorandum and articles of association of the ISAE. These are only to serve as guidelines. Though on one hand, the constitution can be brief and to the point, while on the other hand care should be taken to provide for difficult situations and possible eventualities. The rules should clearly provide for amandments and the winding up of the society, if required later.

The society can be registered with the appropriate authorities as a company or society. A sample of certificate issued by authorities is contained in the Appendix 8.3. Many countries permit expenses incurred on such organizations to be tax free. Individuals/companise paying subscriptions and/or donating money to registered societies can claim deduction of expense from their income for purpose of income tax. Such a registration for tax purposes is important and is of great help inang funds.

Spheres of influence

Professional organizations devoted to development of agricultural machinery manufacture need the support, co-operation and guidance of the government, the financing institutions, the academy and the users. Some important areas in which organizations can influence are:

Within its own membership:

Development of the industry;

Responsibilities to the community and the industry:

Improved standards of trade, higher ethics of business, healthy competition, better quality of products and services, reasonable pricing, higher technology, development of markets, higher productivity:

Planning, assessment of demand, technological foreacasting;

Efforts to solve common problems in production, financa and marketing.

With the Government:

Policy matters;

Laws, rules, regulations, control orders and procedures;

Taxes and levies including Corporats taxation, incomes tax, sales tax- octroi, case, import duty, excise duty, export levy, refund, drewbacks and entitlements;

Planning;

Development of the industry;

Programmes in the field of research, training and extension;

Pricing and fair returns.

With the financing institutions:

Guidance in financial management;

Financing policies and procedures;

Technical guidance and services to borrowers in procurement of products and services;

Adequate funds, reasonable cost of finance;

Priorites.

With the Academic institutions:

Technical guidance;

Research and Development, testing and evaluation;

Safety;

Extension and training.

Market research and surveys.

With others:

(a) Carriers
: Freight rates, safe and prompt transport

(b) Underwriters
: Adeq ate coverago, economical rates, prompt and fair settlement of claims.

(c) Labour
: Higher productivity, fair wages, proper working conditions.

(d) Farmer (User)
: Quality of product and services, prompt payments, co-operation in product development, trials and demonstrations.

(e) Other professional groups
: Common problems, exchange of views and experience, pooling of resources and facilities.

(f) General public
: Creation of a good image.

Summary

Professional societies/organizations can play an important rols in national/regional development of agricultural machinery industry in developing countries. The scope of activities will vary according to types of organizations and local conditions, but important areas they can cover can include:

(1) Marketing problems:
Assesement of demand, technological forecasting, development of markets, rural marketing, market research and surveys.

(2) Financing problems:
Finance from factory to farm; aggregate requirements, procedures, guidence and technical asaistance.

(3) Production problems:
Raw materials and components, quality, standardization, economy of scale of production, coats, research and development.

(4) Laws, rules, regulations and

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The world agricultural situation

by U.S. Department of agriculture (Economic research service, Dec. 1974)

Summary

World agricultural production (excluding Centrally Planned Asian Economies) totaled about the same in 1974 as in 1973, contrary to the general trend in agricultural production in recent years. During the past two decades, production had declined only once in 1972. The lack of expansion in 1974 resulted primarily from decreased output in the United States, Canada, the USSR, and South Asia. World agricultural production remained at 130 (1961-65=100) and production per capita decreased to 106 from 108 in 1973.

Both total and per capita agricultural production for the developed countries declined. Unfavorable weather in these countries at critical periods in the grain cropping season held production to levels lower than expected. Western Europe experienced widespread drought in March-June, and damaging rains in July, but still managed to increase grain output. Canada and the United States had declines in 1974 in both total and per capita agricultural production. In Australia and New Zealand, grain crops increased, and total agricultural production is up over calendar year 1973. South Africa's corn crop for the marketing year May 1974-April 1975 is more than double last year's drought-stricken crop, and its total production is well over the 1973/74 level.

Japan is reducing feed grain imports in 1974/75, and suspending beef imports because its real disposable income has fallen and the price of domestically produced dairy beef has declined, and because U.S. feed grain prices are high and supplies tight.

The economic and monetary climate of the developed countries is generally not healthy. Most OECD countries are experiencing high unemployment rates, balance-of-payments deficits, especially due to the oil crisis, strikes, and inflation. The real GNP for 1974 for the idustrial nations as a whole is estimated to be about equal last year's level.

Agricultural production for the less developed countries (LDC's) rose in calendar year 1974, but per capita production declined. Agricultural production in developing Asia during 1974 probably was about 2 percent less than in 1973. Per capita production will be down about 5 percent, although many countries in the region had increases. Developing Asia's rice crop is now estimated at 102 million tons, a decline of more than 3 percent. Poor

Table 1. Indices of agricultural production in the world and major regions and countries, 1965-74

	1965	1966	1967	1968	1969	1970	1971	1972	1973	Preliminary 1974
World agricultural production 1/	104	108	112	116	117	120	125	123	130	130
Developed countries 2/	104	110	113	117	116	118	123	122	129	128
Less developed countries 3/	104	106	110	114	120	124	127	125	131	133
Per capita world agricultural production 1/	100	102	104	106	104	105	107	104	108	106
Developed countries 2/	102	106	108	111	109	110	114	112	117	115
Less developed countries 3/	99	98	100	101	103	104	104	100	102	101
Regional agricultural production										
United States	104	102	107	109	110	109	118	118	120	117
Canada	112	126	108	117	123	112	129	120	123	114
Latin America	109	108	113	113	118	122	126	125	132	138
Western Europe	103	104	112	114	112	113	120	119	121	123
European Community	103	104	112	114	112	112	119	118	120	122
European Free Trade Association	99	99	107	111	106	110	113	111	112	116
Other Western Europe	105	109	115	120	118	123	136	132	133	139
Eastern Europe	105	115	118	120	119	116	122	132	135	135
USSR	103	122	120	129	123	136	135	129	154	147
Japan	103	106	115	119	115	109	102	110	110	111
South Asia	98	97	106	113	119	126	127	119	130	122
West Asia	105	111	120	125	122	124	131	138	127	137
Other East Asia	107	114	112	117	124	130	134	132	144	151
Africa (excluding Rep. South Africa)	105	106	107	110	118	117	120	123	120	125
Republic of South Africa	96	104	131	113	118	121	134	141	117	144
Oceania	101	114	107	124	121	119	123	116	118	120

1/ Excludes Communist Asia.
2/ North America, Europe, USSR, Japan, Republic of South Africa, Australia, and New Zealand.
3/ Latin America, Asia (except Japan and Communist Asia), and Africa (except Republic of South Africa).

monsoon rainfall in India, and flooding in Burma and Bangladesh did extensive damage to crops. Latin America's 1974 harvests are forecast to exceed the 1973 record by 4 percent. This increased production is expected to reduce regional import requirements below record 1973/74 levels and increase supplies of coffee, sugar, grains, and oilseeds available for next year's exports. Indications point to improved agricultural production for most of Africa, with total agricultural production estimated to be up about 4 percent during 1974/75.

In the centrally planned economies, the outlook for agricultural production is mixed. The USSR experienced a decline in calendar year 1974 in total and per capita agricultral production. The total grain crop including pulses is estimated to be about 200 million tons and USSR imports of grain will total about 6 million tons, which could make the USSR a net importer of about 1 million tons. The People's Republic of China expects a good grain crop in 1974, totaling about 250 million metric tons. Reports indicate a sharp drop in imports because of the adequate crops. Agricultural production in Eastern Europe remains the same as last year. The corn harvest was reduced but because of bumper wheat and barley crops, the total grain harvest will be about the same as the 86 million-ton record of the past 2 years.

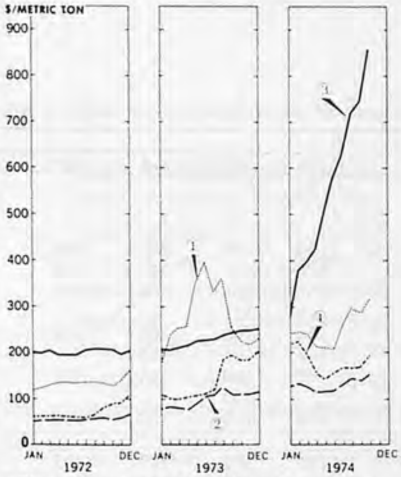


Fig. 1 International trade price of commodities, monthly, 1972-74 ① U.S. No.1 soybeans ② U.S. No.2 yellow corn ③ U.S. No.10 raw sugar ④ U.S. No.1 hard winter wheat, ordinary protein. (①②④=f.o.b. track, Gulf ports, ③=duty paid, New York)

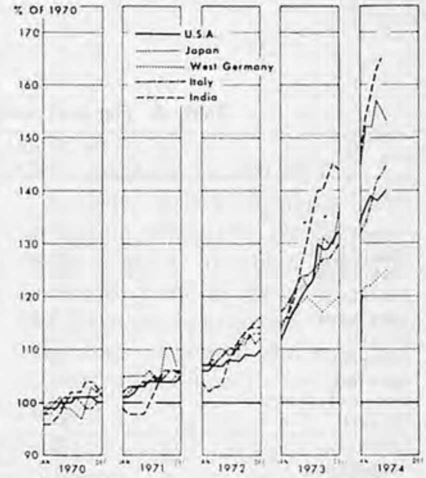


Fig. 2 Consumer price index for food in selected countries

DelegateS to the United Nations' World Food Conference in Rome, November 5-16, adopted 19 resolutions. Some of the major achievements of the Conference are the following :※

(1) A goal of 10 million tons of grain per year for food aid, beginning in 1975, is recommended;

(2) Endorsement of the Food

※For more details on the Conference and the world food situation, see The World Food Situation and Prospects to 1985. Economic Research Service, December 1974.

Table 2. Index of producer prices for agricultural products in selected countries

Country	Fourth Quarter 1973	1974 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct
		1973 = 100									
Belgium	95	94	95	95	91	91	86				
Canada	106	123	123	120	121	123	122	123			
France	100	99	99	99	98	98	98				
Germany, West	106	101	100								
Ireland	103	102	102	102	106						
Italy	106										
Japan	108	112	118	116	120	115	109	115			
Netherlands	95	101	100	97	95						
Norway	91										
New Zealand	106	99									
Spain	100	99	101	99	101						
Sweden	105	107	108								
United Kingdom	114	118	113	112	108	103					
United States	106	115	117	113	94	102	96	102	105	103	108

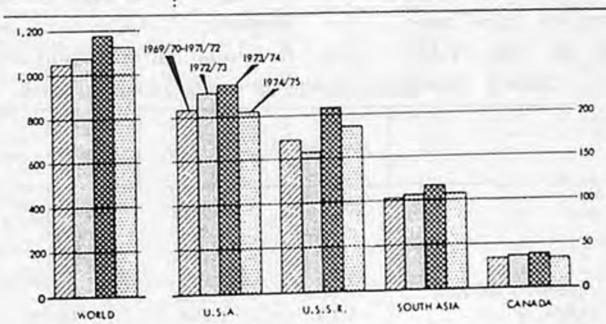


Fig. 3 Total grain production* crop years (mil. metoric tons.* Wheat, rice (milled) and coorse grain (corn, rye, barley, oats and sorghum)

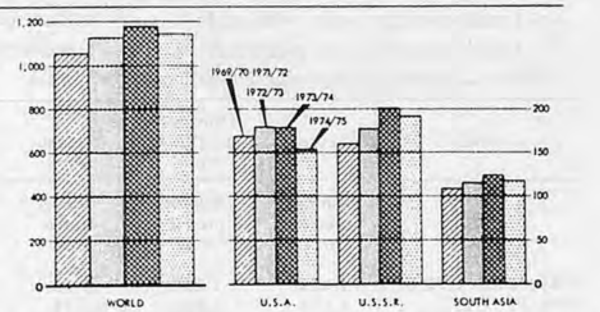


Fig. 4 Total grain disappearance* crop years (mil. metoric tons.* Wheat, rice (milled), and coorse grains (corn, rye, barley, oats and sorghum)

Table 3. The food component of the consumer price index in selected countries (1973=100)

Country	Fourth Quarter 1973	1974 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Argentina	106	103	105	105	106	108				
Australia	107	110	111	112	114					
Austria	103	106	106	106	107	107	110			
Bangladesh	115	119	121							
Belgium	103	104	105	106	105	109	109	112		
Cameroon	98	101	106	110						
Canada	106	107	110	111	111	114	116			
Czechoslovakia	100		100			100				
Denmark	104	106	105	107	109	109	110	112		
Egypt	105									
Ethiopia	100	108	108	107	107	108	113	109		
France	105	106	107	108	110	111	112	113		
Germany, West	101	103	103	103	104	105	106	105		
Greece	115	121	123	123	125	129	130	128		
Guatamala	106	107	104	105	108	107				
India	110	112	114	117	121	126				
Indonesia	113	130	135	137	144	141	140			
Iran	102	105	109	112	115	120				
Ireland	103		106			112				
Israel	109	117	138	139						
Italy	103	106	109	111	113	113	115	117		
Japan	106	117	122	123	127	125	123			
Jordan	110	128	126	138	156	141				
Korea	104	113	119	124	125	125	121			
Liberia	103									
Madagascar	106	114	119	127	131	134	133			
Malawi	104	108	110	119	114	110	111			
Malaysia	113	117	124	127	124	126				
Mexico	114	126	128	129	130					
Morocco	107	118	119	120	121					
Mozambique	102	116	117	116						
Netherlands	103	105	105	105	105	105	106	107		
New Zealand	106	107	108	110	110	109	110	111		
Niger	103	101	103	99	102					
Nigeria	105	112	115	116						
Pakistan	115									
Paraguay	101	120	137		124	124	124	120		
Peru	104	107	110	112	113	117	134			
Phillippines	115	122	128	130	136					
Poland	101		106							
Portugal	108	111	118	121	125	127	127			
Republic of South Africa	105	106								
Singapore	118	124	126	126	122	122	123			
Spain	106	107	107	108	110	111				
Sri Lanka	108	110	110	110	111	112	112	113		
Sweden	102	104	105	106	103	103	104			
Thailand	106	112	117	122	128	134				
Turkey	105	107	107	109	113	116				
United Kingdom	104	109	110	111	113	115	116	116		
Uruguay	123	134	137	139						
USA	106	109	111	113	112	113	114			
Yugoslavia	105	111	111	112	113	115	120			
Zaire	88	100	109	105	109	109	111			
Zambia	98	102	102	103	103	103				

and Agriculture Organization proposal, International Undertaking on World Food Security, to establish a world network of national grain reserves. The undertaking, to have been considered by the FAO Council in November 1974, will take some time to implement;

(3) A Global Information and

Table 4. World grain production and trend estimates

Year	Actual	1960/61-1973/74 trend	Actual-trend
	Million metric tons	*Million metric tons*	*Million metric tons*
1969/70-1971/72 ..	1,059	1,056	+3
1971/72	1,116	1,085	+31
1972/73	1,083	1,114	-31
1973/74	1,181	1,143	+38
1974/75	1,122	1,172	-50

Table 5. World grain consumption and trend estimates

	Actual	1960-73 trend	Actual minus trend
	Million metric tons	*Million metric tons*	*Million metric tons*
1969/70-1971/72	1,068	1,066	+2
1971/72	1,097	1,096	+1
1972/73	1,131	1,126	+5
1973/74	1,180	1,155	+25
1974/75	1,148	1,185	-37

Early Warning System on Food and Agriculture to be operated and supervised by FAO;

(4) Recognition that trade plays an important role in meeting world food challenges and to this end, trade barriers and restrictions should be eliminated;

(5) Establishment of a World Food Council of about 25 members to guide world agencies in coordinating, consulting, and advising on matters related to food security.

A wide variety of actual and potential transfer mechanisms could be used, of which bilateral food aid, such as the U.S. P.L. 480 program, is only one. P.L. 480 shipments of wheat and rice are currently projected to be in

Table 6. World wheat production, consumption and net exports

Region or Country	1969/70-1971/72			1972/73			1973/74			1974/75		
	Production	Consumption	Net exports	Production	Consumption	Net exports	Production	Consumption	Net exports	Production	Consumption	Net exports
	Thousand metric tons											
Developed	112,005	87,500	28,815	116,805	91,415	45,630	127,960	85,684	44,840	130,230	83,395	45,065
U.S.	40,025	21,900	17,709	42,045	21,815	31,770	46,570	20,604	31,245	48,480	19,425	28,580
Canada	13,900	4,670	11,660	14,515	4,765	15,690	16,460	4,650	11,425	13,435	4,950	11,330
EC-9	36,860	40,660	-3,300	41,435	43,705	-755	41,365	39,915	320	44,270	42,660	1,865
OWE	9,885	10,680	-710	9,950	10,490	-230	9,335	9,750	-710	10,980	10,375	270
South Africa	1,460	1,340	-60	1,745	1,475	345	1,835	1,505	425	1,645	1,590	-15
Japan	560	5,255	-4,695	285	5,560	-5,445	200	5,645	-5,325	230	5,790	-5,730
Australia/New Zealand	9,315	2,995	8,220	6,830	3,605	4,255	12,195	3,615	7,460	11,190	3,625	8,765
Centrally Planned	142,900	154,495	-3,735	144,640	167,470	-22,630	169,240	169,025	-9,225	151,555	164,725	-9,220
Eastern Europe	26,260	31,075	-4,620	30,645	34,590	-3,745	31,560	35,040	-3,920	33,855	36,530	-2,725
Soviet Union 1/	92,305	95,670	4,800	85,995	99,595	-13,600	109,680	100,080	600	90,000	93,000	1,000
People's Republic of China	23,835	27,750	-3,915	28,000	33,285	-5,285	28,000	33,905	-5,905	27,700	35,195	-7,495
Developing	64,171	85,070	-22,126	73,261	97,195	-21,710	69,483	100,926	-29,492	69,620	100,195	-30,449
Mexico/Central America	2,060	2,910	-811	1,745	3,270	-1,425	2,038	3,558	-1,584	2,238	3,778	-1,622
Venezuela	1	710	-710	1	690	-635	1	580	-580	1	600	-600
Brazil	1,785	3,780	-1,830	800	3,825	-2,965	1,930	4,200	-2,810	2,500	4,800	-2,240
Argentina	5,875	4,170	1,685	6,900	4,110	2,875	6,700	4,500	2,000	6,500	4,550	2,000
Other South America	1,940	3,800	-1,840	1,260	4,195	-2,915	1,390	4,295	-2,840	1,780	4,150	-2,325
North Africa/Middle East	20,510	28,300	-7,970	24,470	31,035	-6,300	19,865	31,515	-10,370	22,361	33,365	-11,665
Central Africa	860	1,955	-1,105	940	2,035	-1,140	865	2,110	-1,250	770	2,130	-1,415
East Africa	310	605	-270	285	665	-320	263	710	-440	245	700	-455
South Asia	30,445	34,050	-4,750	36,565	42,135	-4,035	36,218	44,688	-6,619	33,025	41,163	-7,440
South East Asia	35	430	-395	50	535	-475	50	463	-410	50	469	-415
East Asia	350	4,360	-4,130	245	4,700	-4,375	163	4,307	-4,589	150	4,490	-4,272
Rest of world	315	2,165	-1,850	355	2,260	-1,905	370	1.910	-1.540	370	2.015	-1,645
Total above	319,391	329,230	1,104	335,061	358,240	-615	367,053	357,545	4,583	351,775	355,330	3,751
World total	319,391	330,334		335,061	358,240		367,053	361,609	2/	351,775	359,081	2/

1/ Official data. Production figures refer to grain as threshed, often containing excess moisture and dockage. Trade figures exclude exports donated for aid and assistance.
2/ Conceptually, net world exports are impossible. Differences between world totals for exports and imports are due to statistical discrepancies.
November 15, 1974

Table 7. World coarse grain production, consumption and net exports 1/

Region or Country	1969/70-1971/72			1972/73			1973/74			1974/75		
	Production	Consumption	Net exports	Production	Consumption	Net exports	Production	Consumption	Net exports	Production	Consumption	Net exports
	Thousand metric tons											
Developed	273,324	272,485	982	290,195	292,640	14,668	305,030	299,470	12,935	266,235	274,065	6,260
U.S.	165,830	145,785	20,355	182,130	157,415	39,535	186,700	155,815	40,970	149,865	132,280	28,210
Canada	18,495	15,415	3,240	18,790	15,920	3,210	18,395	16,505	1,685	16,265	15,610	2,520
EC-9	55,875	69,330	-13,225	60,810	72,720	-12,455	63,330	76,775	-13,365	61,675	74,275	-11,900
OWE	18,324	22,135	-4,003	19,485	24,900	-5,002	19,320	27,145	-8,175	22,005	28,055	-5,805
South Africa	8,680	5,700	2,590	4,520	5,975	140	11,770	6,710	3,700	9,670	6,710	3,845
Japan	725	10,945	-10,265	405	12,355	-12,130	275	13,760	-14,110	275	13,985	-13,280
Australia/New Zealand	5,395	3,175	2,290	4,055	3,355	1,370	5,240	2,760	+2,230	6,480	3,150	+2,670
Centrally Planned	151,310	156,085	-3,315	155,350	165,200	-10,695	183,985	190,220	-8.185	180,245	188,815	-6,310
Eastern Europe	47,340	50,145	-2,680	55,180	59,270	-4,025	54,465	55,645	-1,130	52,345	55,885	-3,280
Soviet Union 2/	71,335	73,210	-540	70,370	75,360	-5,900	96,620	99,545	-4,925	95,000	99,030	-2,030
China	32,635	32,730	-95	29,800	30,570	-770	32,900	35,030	-2,130	32,900	33,900	-1,000
Developing	109,480	104,220	5,400	107,365	108,805	1,105	114,124	111,219	2,722	114,670	111,909	3,491
Mexico/Central America	13,025	13,210	-135	12,215	14,075	-1,810	13,780	15,105	-2,065	12,785	15,400	-2,040
Venezuela	700	945	-260	515	1,340	-630	415	1,115	-700	530	1,295	-750
Brazil	14,555	14,135	910	14,240	15,110	-20	15,420	14,885	540	16,240	15,400	840
Argentina	13,185	6,435	6,465	15,735	7,955	7,905	17,635	8,230	9,400	17,840	7,835	10,005
Other South America	3,665	4,055	-390	3,820	4,150	-535	3,805	4,550	-730	4,155	4,745	-530
North Africa/Middle East	16,330	17,705	-1,220	16,980	18,730	-1,365	14,655	17,510	-2,525	16,795	19,100	-2,350
Central Africa	12,145	12,220	-75	11,945	12,160	-210	11,320	11,580	-260	11,670	11,510	-185
East Africa	6,610	6,265	-20	6,160	6,045	935	7,765	6,917	+1,092	7,150	6,860	+313
South Asia	20,175	20,625	-105	18,205	19,215	-920	19,709	21,449	-1,647	17,704	19,265	-1,417
South East Asia	2,280	475	1,780	1,615	570	1,050	2,751	631	+2,277	2,231	665	+2,040
East Asia	6,810	8,150	-1,550	5,935	9,455	-3,295	6,868	9,247	-2,660	7,070	9,834	-2,435
Rest of world	115	315	-195	125	300	-175	125	418	-293	125	415	-290
Total above	534,229	533,105	2,872	553,035	566,945	4,903	603,264	601,327	2,769	561,275	575,204	3,151
World total	534,229	535,977	3/	553,035	571,848	3/	603,264	604,096	3/	561,275	577,103	3/

1/ Includes corn, barley, rye, oats, and sorghum.
2/ Official data. Production figures refer to grain as threshed, often containing excess moisture and dockage. Trade figures exclude exports donated for aid and assistance.
3/ Conceptually, net world exports are impossible. Differences between world totals for exports and imports are due to statistical discrepancies.
November 15, 1974

excess of 3 million tons for FY 1975, more than in FY 1974, although that projection cannot be regarded as a commitment, since actual quantities are only decided sequentially on a case-by-case basis in accord with agreements negotiated with other governments. As a follow-up to the World Food Conference, representatives from potential donor and recipient nations will be meeting in coming months to reach agreement on methods to carry out grain transfers which cannot be made through normal commercial channels.

The value of U.S. agricultural exports totaled $6.2 billion in the first 4 months of fiscal 1975 compared with $5.9 billion in the same period last year. Continued price increases may raise the value of U.S. agricultural exports in fiscal 1975 above last year's $21.3 billion, although the volume of exports could decline by 20 percent.

The trade bill giving the President new authority in trade negotiations has been reported to the Senate by the Senate Finance Committee. Agricultural trade negotiations will be conducted in conjunction with bargaining about the industrial sector. Multilateral trde negotiations are planned to begin in Geneva next spring.

World prices are generally rising for agricultural commodities, with beef, cotton, and coffee being notable exceptions. The October sugar prices were at least 3½ times last year's prices and will likely continue at record levels as long as reported stocks are at a low level.

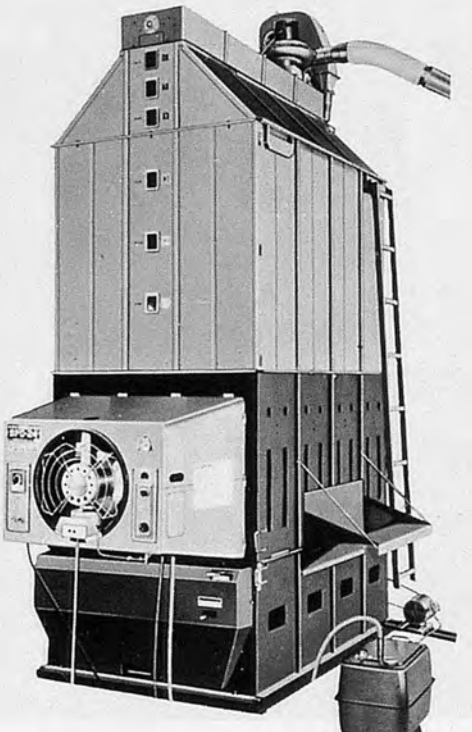
Would grain (including rice) production is now estimated at 1,123 million metric tons, or roughly 4.5 percent below last year's level. This year's production shortfalls were concentrated in the United States, the USSR, and, to a lesser extent, South Asia and Canada.

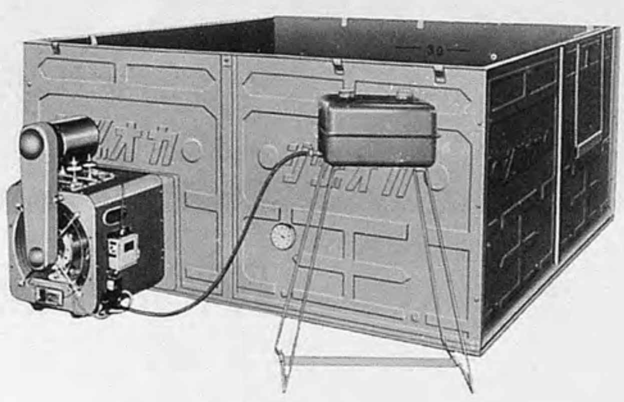
World rice production is also disappointing. It is approximately 4 million tons below trend, leaving most of Southeast Asia in a tight situation. Prices are high, reflecting the short supply.

Table 8. World milled rice production, disappearance and net trade 1/

Country and region	1960/61-1962/63			1969/70-1971/72			1972/73			1973/74			1974/75		
	Production	Disappearance	Net exports	Production	Disappearance	Net exports	Production	Disappearance	Net exports	Production	Disappearance	Net exports	Production	Disappearance	Net exports
	Thousand metric tons														
Developed	14,593	14,222	371	15,581	14,485	2,103	14,755	14,442	2,042	15,474	13,690	1,779	16,356	13,684	2,084
United States	1,867	845	1,022	2,878	1,314	1,719	2,821	1,185	1,771	3,073	1,219	1,639	3,801	1,258	2,129
Canada	--	31	-31	--	60	-60	--	55	-55	--	50	-50	--	50	-55
EC 9	584	784	-200	661	750	-89	557	773	-225	722	871	-19	718	711	-37
Other Western Europe	439	604	-165	450	517	-67	395	458	-62	426	488	-77	450	505	-63
South Africa	1	52	-51	1	77	-76	10	95	-85	10	95	-85	10	100	-90
Japan	11,613	11,866	-253	11,400	11,706	546	10,826	11,836	548	11,056	10,926	210	11,177	11,010	50
Australia & New Zealand	89	40	49	191	61	130	146	40	150	187	41	161	200	50	150
Centrally Planned	55,280	54,781	499	70,308	70,005	303	67,875	67,084	1,155	71,346	70,411	997	71,517	70,729	952
East Europe	90	338	-248	147	403	-256	163	368	-241	162	369	-243	177	369	-228
U.S.S.R.	159	335	-176	831	1,149	-318	1,072	1,176	-104	1,144	1,202	-60	1,300	1,420	-120
China	55,031	54,108	923	69,330	68,453	877	66,640	65,540	1,500	70,040	68,840	1,300	70,040	68,940	1,300
Developing	89,249	89,603	-354	119,064	122,460	-2,639	112,703	119,708	-2,841	124,332	126,793	-4,133	121,787	126,958	-3,651
Mexico/Central America	486	573	-87	719	852	-133	644	703	-79	663	787	-134	673	821	-131
Venezuela	47	53	-6	131	114	17	165	180	1	272	200	72	275	220	55
Brazil	3,569	3,505	64	4,749	4,705	68	4,850	5,000	180	5,100	5,200	20	5,300	5,400	100
Argentina	117	95	22	232	162	70	197	170	30	213	172	42	268	178	90
Other South America	961	960	1	1,402	1,279	123	1,485	1,436	45	1,565	1,594	106	1,594	1,519	165
No. Africa/Middle East	1,724	1,756	-32	2,806	2,826	-20	2,667	3,153	-436	2,493	3,521	-1,033	2,702	3,936	-1,314
Central Africa	1,971	2,407	-436	2,868	3,563	-695	2,890	3,490	-600	3,095	3,795	-700	3,110	3,810	-700
East Africa	144	167	-23	214	235	-21	219	230	-11	215	226	-11	215	226	-11
South Asia	45,752	46,617	-865	57,589	59,206	-884	53,922	55,637	445	61,438	59,511	153	57,339	58,413	205
Southeast Asia	15,844	12,463	3,381	20,535	18,692	1,843	17,670	17,512	623	19,905	18,826	635	18,945	17,774	1,185
East Asia	14,217	16,378	-2,161	22,704	25,468	-2,764	22,594	26,452	-2,694	24,303	27,601	-2,993	26,006	29,021	-3,015
Rest of world	4,417	4,629	-212	5,115	5,358	-243	5,400	5,745	-345	5,070	5,360	-290	5,360	5,640	-280
World total	159,122	158,606	516	204,953	206,950	-233	195,333	201,234	356	211,152	210,894	-1,357	209,660	211,371	-615

1/ Production primarily in initial calendar year combined with trade in the following year to get disappearance in year shown. Disappearances estimates include the effect of stock variations.





Man Tills the Earth's Soil in

"Mother Earth" blesses those who seek her blessings wisely. All human beings should be given an equal opportunity to enjoy the earth's blessings.

This concept of love for humankind and love for earth is the guiding principle on which the SATOH enterprise has labored for the past 50 years. All its agricultural machines and implements are built and developed on this lofty principle.

Among the many manufacturers of agricultural machines and implements in Japan, SATOH enjoys top popularity. Its 300 engineers and other technical experts devote their full time and energy to many research works.

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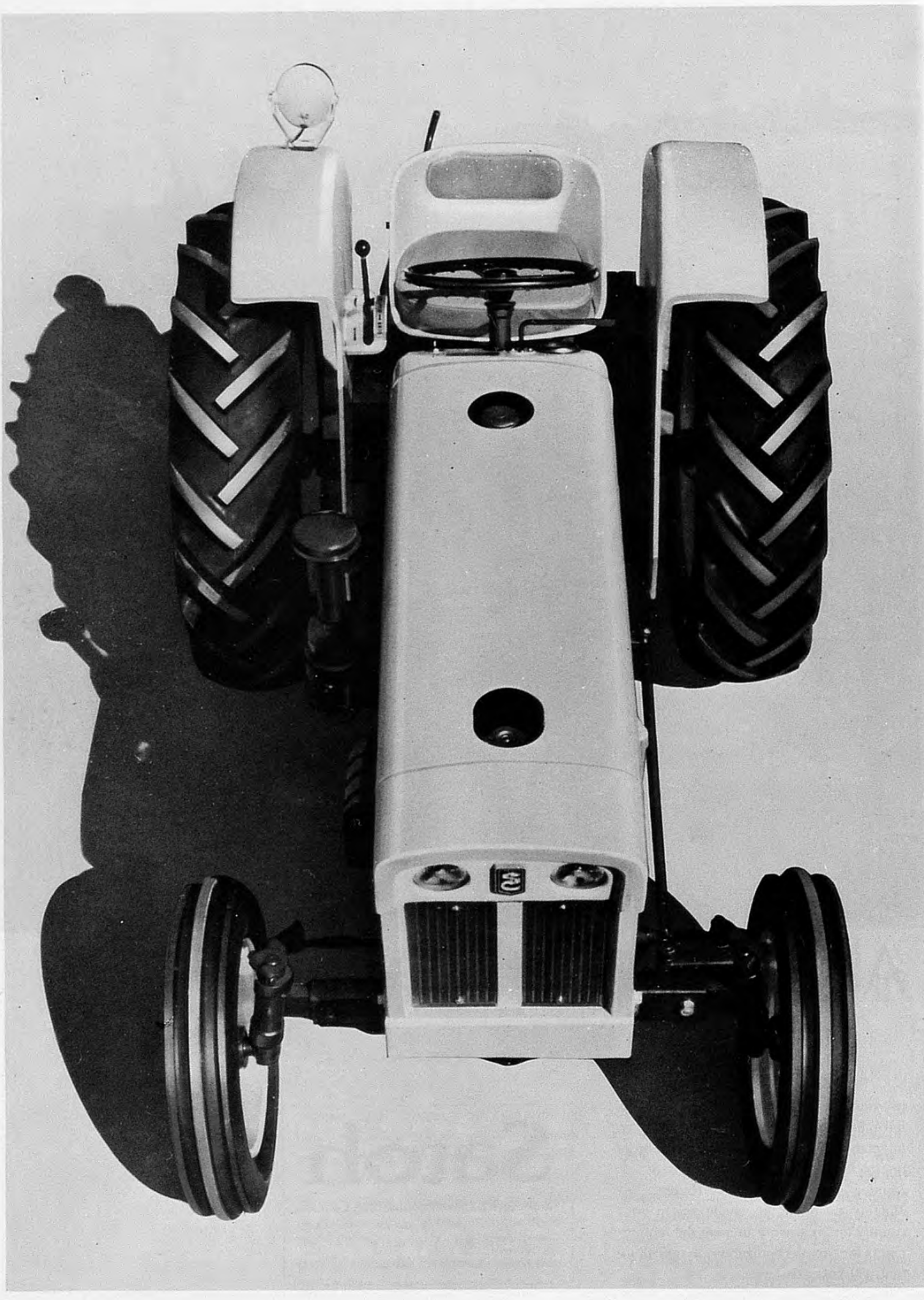

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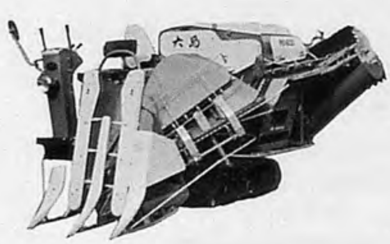
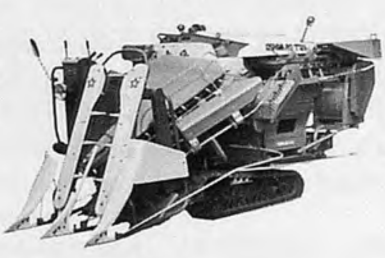
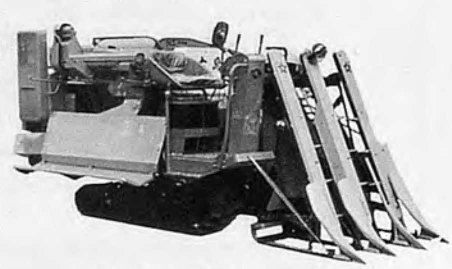


model RS-600 ・600A
Engine=7～9HP ・8～11HP
Cutting wide=650mm 2row cotting
Efficiency=80～120minutes/10ares



model RS-701
Engine=8～11HP
Cutting wide=700mm 2row cutting
Efficiency=60～90minutes/10ares

model RS-771A ・772D
Engine=10～13HP ・11HP
Cutting wide=700mm 2row cutting
Efficiency=60～90minutes/10ares



model RC-901
Engine=11～15HP
Cutting wide=900mm 3row cutting
Efficiency=40～70minutes/10ares

model RC-902D
Engine=15HP
Cutting wide=900mm 3row cutting
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News

Agricultural Engineering Research in Denmark

by
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Hisamitsu Takai
Agricultural Engineering Institute, Denmark

Research Works of Agricultural Engineering Institute※

Research in the agricultural engineering area in Denmark is mainly performed at the Agricultural Engineering Institute at the Royal Veterinary—and Agricultural University, the Governmental Testing Station for Agricultural Machinery, the Danish National Institute of Building Research, which has a special department for agriculture buildings, and at the Biotechnical Institute. The testing station and the biotechnical institute are located in Jylland, while the two others are located in or close to Copenhagenn.

It is only my task to write about the agricultural engineering research performed at the university where both basic and applied research is carried out at the agricultural engineering institute.

Seed bed preparation for row crops, especially sugar beets, is a project just finished. The objective was to find parameters which in numbers will describe what the practical farmer normally calls "a good seedbed". The research so far has shown that that there is many parameters—so many in fact, that it is very difficult to set up a mathematical description of the socalled good seedbed. The research, however, clearly showed, that seeding the sugar beets directly in the fallplowed field—minimum tillage—with a special machine developped during the research gave the highest rate of germination. Furthermore this new combined seedbed preparation and sowing method gave especially a better germination, when severe dry weather condition followed the sowing of the beets. Under conditions with sufficient precepitation the method of sowing is less important.

Just started is another more theoretical project connected with determination of the soil structure by means of new non-destructional methods. It is an interscandinavian project, where scientists and engineers from 3 countries is trying to find new, easier and better ways of measuring different characteristics of the soil. So far the use X-rays, ultrasonics, sound-absorption and air permeability is being investigated. It is, however, too early to discuss any results from this project, but some promising trends have shown.

The increase in oil prices and other fusile fuels in the western world and elsewhere has caused an increase in the research for other types of energy resources and energy-saving methods. At the institute investigation on the reuse of waste heat from the ventilation air of animals housing areas, cow barns, pig houses etc., has been started recently together with utilizing the heat pump for heating farm houses. Also in this connection an experiment utilizing the heat generated by fermentation of manure is being looked into by means of a pilot plant.

Denmark os located in an area with prevailing western winds. This together with the fact that Denmark is a small country surrounded by sea causes the average wind velocity to be rather high, and hence a possibility for utilizing wind energy should be obvious. Before 1914 wind energy was used to some degree for pulling threshing machines, grinders and other stationary machines on the farm. After introduction of electricity produced—first on the basis of coal and later on the basis of oil—industry and agriculture had a much cheaper and more con-

※by T. Tougaard Pedersen

venient energy resource than the wind. The oil crises recently, the increasing prices and the apparently limited amount of fusile fuel has caused renewed interest for utilizing the wind as an energy resource. A small windmill has been constructed at the institute. The windenergy here is transferred direct into heat, which can be stored in water tanks or used directly for heating purposes.

The lack of man power in agriculture many places in Europe and elsewhere has required that more and more farmwork can be performed per man hour. So far this has been fullfilled by making the tractors as well as the machines still bigger and bigger. This trend has been going on for the last 40 years, but the limit in tractor size as well as working width of the machines seems soon to be reached. The amount of soil compaction, which can be tolerated is going to set the limit for the weight of tractors and agricultural machines, and the uneveness of the surface of the field will in many areas set the limit for the working width of the machines and implements.

One of the possibilities to increase the capacity per man hour exists in a master and slave system. The tractor driver in such a system drives the master tractor or a self propelled machine, and one or even more tractors or machines follows in a certain position from the master. The slave can be directed either through a mechanical link or governed by radio signals. A master and slave system has been developped at the institute and seems to work quite well with one slave implement guided through a mechanical link. However, if it is going to be developped with more than one slave unit for each master, radiosignals must autmatically control speed, location and adjustments of the slaves. Research with radiocontrolled slave tractor and implements is now being performed at the institute.

Conservation of grain under tropical and subtropical conditions has mostly been performed by drying. However, under the hot and humid conditions which exist in many of the areas, where rice is grown, it might be a question, if it not is worth while to try to find other methods to conserve even rice for human consumption. Pilot research with barley in climatic chambers where temperature and relative humidy was controlled and changed have indicated that small amounts of propionic acid, 0.2%, might be able to conserve grain under tropical conditions, if the acid is evenly distributed throughout the grain. The pilot research also showed that mould growth first of all is dependent upon the absolute moisture content in the air. These pilot research is continued on a bigger scale, where a japanese graduate student now is trying to find a method of conserving raw rice by means of chemicals which might be fully or partly removed when the raw rice is prepared for human consumption. If a simple method of conservation can be found, much rice which now is destroyed by high moisture content followed by mould growth and bacterial action, can be saved and help to decrease the lack of food in many development countries.

Some Research Works of Other Institutes**

Some of the most recent research works carried out by Danish instituts, F.H.I.(1) and S.B.I.(2) are probably useful for the Asian agriculture.

A flexible silo made by P.V.C. or butyl-rubber, as an interim report of F.H.I. said, has many advantages compared with an air-tight silo of solid materials:

1) Higher concentration of the carbon dixide will be obtained.
2) This needs less requirement for the air-tightness of the constructions.
3) Better preservation of the protein will be carried out.
4) The grain stored in the silo has better flow-character.

Afla-toxin, as it is well known, can be distroyed by ammonium-treatment with high temperature and high pressure. But the method is too expensive to be used in practical way. F.H.I. is making effort in order to find an economical method. Under the pelleting process, the materials will be exposed to high temperature and high pressure. Giving the ammonium-treatment under the pelletting process is not inconceivable.

Surplus straw can be used as building and furniture materials. A method of making straw-chip-board has been developed by F.H.I.. This board is as hard as wood-chip-board. F.H.I. is also researching the effective use of the straw as feed.

A group of experts at S.B.I. is now trying to observe and measure the climate in a pigsty. This deep study has an aim of establishing the optimum air conditions for pig raising, and developing the suitable ventilation systems. They are also testing a deodorization system. A stench from pigsty will be absorbed by the water which is attached on the surfaces of a lot of small plastic balls. The installation tested showed that it can reduce 80% of the stench.

**by Hisamitsu Takai

(1)F.H.I. : Biotechnical Institute (Before named: Research Institute for Plants used for Industrial Purposes) address: 6,000 Kolding, Denmark.

(2)S.B.I. : Danish National Institute of Building Research address: Forskningscentret, 2,970 Høsholm, Denmark.

Computer Aided Selection and Costing of Farm Machinery Systems

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Introduction

The proper choice of power units and their machinery complements for farming operations is very important. In order for farms to operate efficiently, the size and number of tractors and equipment should match the power required by the various sequences of cropping operations which must be performed within specific time periods during the year. The annual use and operating costs of the power units and machinery also need to be considered in selecting equipment. Procedures for performing hand calculations to size and select machinery exist (Van Gilst, 1974). These methods, however, are time consuming and laborous for even a few sets of operations. Thus, cost comparisons of alternative sizes of tractors and machines for performing cropping operations are usually precluded when using hand calcualtions. For this reason, selection and costing of tractor and machinery systems using a computer appear desirable.

A computer program for machinery selection is most useful, however, when there is an interactive exchange of information during program operation between the computer and the person desiring selection of the machinery. Access to this interactive capability on large computers is often limited and expensive. Since smaller desk top or mini-computers which provide an interactive capability are becoming increasingly available, the computer program discussed in this paper was developed for use in desk top computers which are programmable in BASIC computer language and have a minimum of 8192 bytes of storage.* The machinery selection program is segmented into four subprograms stored on cassette tape and sequentially loaded as each portion of the program is completed.

The computer model was adapted from work done by Harold Hughes (Hughes, 1973 and Hughes, et al., 1973).

The machinery model selects a machinery complement, including power units, which is capable of performing all field operations at a rate sufficient to achieve a successful crop. The model begins by estimating horsepower needed for the cropping operations. Second, the tractors are selected and assigned to field operations. Third, machine size is matched to operation requirements. Finally, yearly use, operating costs and fossil fuel requirements are determind.

Energy Requirement Subprogram

Power required for field operations depends on the amount of work to be done and the time available. Work to be done depends on: 1) the acreage of each crop to be grown, 2) soil characteristics, 3) field operations required for planting, cultivating, and harvesting the crops and 4) the technology (kinds of machines) being used. The time available for completion of field work depends on: 1) weather and soil characteristics, 2) hours worked per day, 3) number of days allowed for completion of field operations, 4) scheduling

※ The program has been run on a WANG 2200-B programmable calculation with 8K of storage. The authors will provide additional information concerning the model upon request.

efficiency 5) machine reliability and 6) field efficiency.

Field Operations

The set of field operations to be performed depends on the crops to be produced and the production technology adopted.

The set of field operations are organized into subsets. Each subset is a group of field operations that must be performed either simultaneously or sequentially during a specific time period. No particular order of operations within the subset is assumed.

A subset can consist of a single field operation, such as combining grain corn or it may include several operations such as the plowing, tilling, and planting. Starting and ending dates for each subset may be dictated by cropping characteristics, by weather and soil conditions, or by management requirements.

Theoretical Energy

Theoretical energy is the energy, in horsepower-hours, that would be consumed in performing a particular field operation if there were no field inefficiencies such as wheel slippage, overlap, etc. Theoretical energy consumption by a field machine is situation specific and depends on factors such as soil characteristics, crop yields and machine characteristics.

For some field operations, theoretical energy is related to operating speed. For these operations (plowing) the model requires that machine speed is restricated to a range which is narrow enough to justify assuming speed independence. Thus, theoretical energy is not a function of machine size or speed.

Total theoretical energy required for a field operation is the product of the theoretical energy per acre and the acreage for which the field operation is required.

Effective Energy

Field efficiency is a measure of time losses in the field due to overlap, wheel slippage, turning, plugging, etc. Several of these factors increase the energy that must be expended before a field operation a particular area is completed, and all of them require that the rate of energy expenditure (power) be increased if the operation and others in the same subset are to be completed without violating the subset time constraints.

The total effective energy required for each field operation is the total theoretical energy divided by the field efficiency. The total effective energy for a subset is found by addition the total effective energies for all field operations in the subset.

Subset Time

Time available for completing the operations in a subset depends on: 1) hours the machines work per day, 2) number of working days for completion of the subset, 3) percentage of working days that are usable and 4) machinery system reliability.

The hours of machine use per day equals the operator's nominal work day less the time spent in road travel, hitching and other activities that take place outside the field. Scheduling efficiency, the percent of scheduled work time that the machine and operator are in the field, is a measure of this type of time use.

The percent usable work days, is location specific and based on the expected number of days that soil and climatic conditions would permit crop operations to be performed during the subset.

The number of working days is the number of days from the beginning to the ending dates for the subset, less days when no work is done, such as Sundays and holidays.

Machinery reliability is a measure of the percentage of time, when the machine is the field, that it is in operating condition. Time lost because of repairs reduces the time available for completing the operation. Machine system reliability is an overall figure applied to all machines in the system.

The total effective horsepower needed for the operations in each subset is found by dividing the effective energy required for the subset by the subset time.

The set of effective horsepower requirements by subset gives the distribution of horsepower requirements throughout the year. Often power reductions are possible by modification of the order of operations, time constraints or the production technology. If any reduction can be made, the energy requirement portion of the model can be re-executed before preceding to the next part of the model.

The effective horsepower required for the system is the maximum of that required for any one subset in which tractors are used. It should be noted, however, that effective horsepower is the minimum that is capable of completing the field operations under the assumed conditions. If conditions are such that more power is required than has been estimated, the effective horsepower would not be adequate and either the work schedule would have to be extended or the quantity of work reduced.

To circumvent this possibility, the effective system horsepower is increased by 25% to obtain a design horsepower. The additional horsepower is available for handling unexpected situations such as extra field operations, modified soil conditions, etc. Another effect of increasing the power is that the average loading

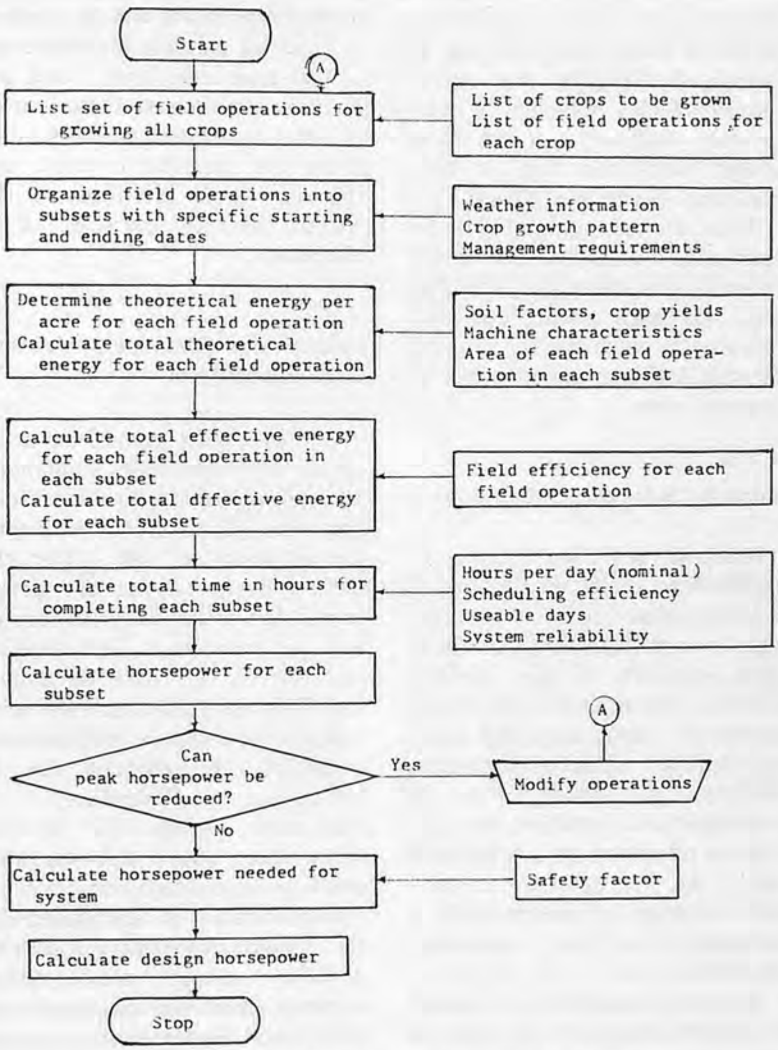

Fig. 1. Procedure for estimating horsepower requirement

rate of the tractor is reduced. This promotes longer endine life and higher reliability.

The power determination has been made by use of anticipated loads on the tractor. Thus, the power requirements that have been estimated are all drawbar horsepower. The procedure for estimating horsepower requirements is shown in **figure 1.**

Self-propelled Machines

The preceeding discussion was for tractor powered machines. Obviously, all operations do not require input of tractor power. The selection model can also be used for self-propelled machines. The only restriction is that self-propelled machine operations must be placed in subsets separate from tractor powered operations. The subset dates can overlap the tractor powered subsets, since separate equipment is to be used in each.

self-propelled machine power is then calculated in a way similar to the tractor powered operations.

Tractor Selection Subprogram

The size and number of tractors needed depend on the design horsepower for the system and the size range of tractors available on the market. The number of tractors must, of necessity, be an integer. Many combinations of tractors with total horsepower equal to the required design horsepower are usually available.

The criteria used in the model to determine the number of tractors to be purchased is to select the minimum number of tractors which match the design horsepower. The model thus selects tractors equal to the maximum horsepower size until the total horsepower equals or exceeds the required design horsepower. If the total horsepower of the tractors selected exceeds the design horsepower, tractors are set equal to the minimum tractor horsepower one at a time until the total horsepower is less than or equal to design horsepower. For the situation where tractor horsepower becomes less than the total required, the last tractor whose horsepower was equal to the minimum is increased by the horsepower increment until the total again equals or exceeds the design horsepower.

Allocation of Tractor Energy to Subset

A work schedule must be constructed for assigning work to each tractor before equipment can be selected for the different farming operations. First, for each subset the maximum amount of energy that an individual tractor can be expected to develop during the time available in the subset is calculated. It is assumed that the tractor operates at an effective horsepower which is its rated horsepower multiplied by 75 as indicated earlier.

For each subset, the tractors are all checked, from smallest to largest in order, to determine if any one tractor can develop enough energy to power all the field operations in the subset. If one tractor is capable of powering all the work in the subset, then it is assigned to supply all the energy required for that subset of operations.

If no single tractor can power all the operations, then the largest tractor is assigned to work at its maximum capacity, for the total time available in the subset. The procedure is then repeated in allocating the remaining work to the remaining tractors.

After energy to be supplied from each tractor for use in each subset has been allocated, specific field operations in each subset must be assigned to each tractor. If only one tractor is used in a subset, it powers all of the operations.

Allocation of Tractors to Field Operations in a Subset

If a given subset has field operations requiring energy from more than one tractor, the largest tractor scheduled for use during the subset is assumed to power the largest possible portion, of the earliest field operation. If the energy available from the tractor exceeds the energy required for the earliest operation, subsequent operations and/or a fraction of an operation are assigned to this tractor untill the total energy required for the assigned operations equals the energy available from the tractor. Usually this process will leave a fraction of one of the operations unassigned. The unassigned portion of the operation is then taken as the starting point for the assignment of field operations for the next smaller tractor scheduled to power operations in the subset. The procedure is continued until all field operations in the subset are assigned to tractors and is then repeated for the other subsets.

Since the power rating of each tractor and the energy requirement for each field operation are known, the time required to complete each operation can be calculated. Dividing the energy requirement in horsepower hours by the effective tractor horsepower yields the time to complete the operation in hours.

Thus, the acreage and time for each field operation can be calculated. The effective field capacity of each field operation powered by each tractor is found by dividing the acreage by the required time.

Machine Selection Subprogram

Machine selection begins by establishing limits on the size of machines that can be used in the tractor farm operation combinations specified in the previous section. These limits are established by using size and speed constraints. Each particular machine is assumed to be available in a ramge of sizes from a minimum to a maximum with, and to operate properly over a range of speeds from a minimum to the maximum allowable.

When an operation in a subset is divided between tractors, or when the same operation is performed in more than one subset, the time and size limits are checked to determine if the same machine can be applied to more than one of the operations.

If an operation in a subset is performed by more than one tractor, if the size limits overlap, and if the total time for the field operation is less than the subset time, then one machine will satisfy the need. If, on the other hand, time for the field operation exceeds the subset time, multiple machines will be needed.

Similarly, if the same operation is performed in more than one subset, and the size limits overlap, one machine will suffice. If the size limits do not overlap, multiple machines will be needed.

After all possible combinations of this type have been found, the annual time each machine is used is found as the sum of the several times the machine is used, and the size limits are reset to the widest pair that satisfies all of the limits.

Tractor and Machinery Use and Cost Subprogram

In calculating annual costs of owing and operating equipment, an estimate of the machine life is required. This is based upon annual hours of use. After the annual hours of use are determined for a machine, its service life is calculated by dividing machine life in hours by annual use. It is assumed that even with low annual usage, a machine will eventually be replaced due to obosolence. Therefore, a maximum service life of ten years has been chosen for purposes of depreciation.

Depreciation is calculated by the straight line method assuming a 10% salvage value. Other methods, however, can easily be substituted. Repair costs over the life of the machine are taken as a fixed percentage of the original cost of the machine and are prorated according to annual machine use.Annual cost for interest, housing, taxes, and insurence are calculated as annual percentages of the purchase cost less salvage value of the machine.

The self-propelled machines, if any, are selected by the same procedure discussed for the pull type machines. Costs for self-propelled machines and the tractors are evaluated similarly to the machine costs.

Capital requirements in dollars are calculated as the sum of the initial costs of the tractor, tractor drawn machines, and self--propelled machines. Labor re-

Figure 2. Specification of sets of operations and energy requirement determination.

```
Tractor and machinery selection: Energy requirements
Maximium limits: Sets=10, Types of equip=16, Operations=30
Enter workdays/week, workhrs/day, schedule eff., reliability, num machines? 6, 10, 85, 1, 12
Number of sets (1 to 10)? 4
For set 1 begin day, begin mo, end day, end mo, pc usable days, num oper= ? 17, 4, 25, 5, 35, 9, 4
for operation 1 operation id, acreage= ? 1,480
for operation 2 operation id, acreage= ? 3,640
for operation 3 operation id, acreage= ? 4,640
for operation 4 operation id, acreage= ? 6,640
For set 2 begin day, begin mo, end day, end mo, pc usable days, num oper= ? 10, 6, 15, 7, 58.9, 1
for operation 1 operation id, acreage= ? 8,1280
For set 3 begin day, begin mo, end day, end mo, pc usable days, num oper= ? 25, 9, 24, 10, 69.4, 1
for operation 1 operation id, acreage= ? 14,640
For set 4 begin day, begin mo, end day, end mo, pc usable days, num oper= ? 25, 10, 14, 12, 12.8, 2
for operation 1 operation id, acreage= ? 11,640
for operation 2 operation id, acreage= ? 1,160
Plow depth for set 1= ? 8
Row width for set 1= ? 2.5
Row width for set 2= ? 2.5
Rolling resistance, yield for crop in set 3= ? · 25,110
Row width for set 4= ? 2.5
Plow depth for set 4= ? 8
  Set 1      date 17/4   to 25/5   percent usable        days=35.9
operation     energy      hours      horsepower             acres
    1        12673.2      56.9         222.4                480.0
    3         3911.5      17.5         222.4                640.0
    4         2346.9      10.5         222.4                640.0
    6         3466.1      15.5         222.4                640.0
  Total      22397.8     100.6
  Set 2      date 10/6   to 15/7   percent usable        days=58.9
operation     energy      hours      horsepower             acres
    8         3520.3     155.2          22.6               1280.0
  Total       3520.3     155.2
```

quired for the field operations is determined by summing the operating times for tractor drawn and self-propelled machines. Lastly, energy in the form of fossil fuel is determined based upon the energy requirements of all the subsets.

Example

The computer program has been run with a sample farm to illustrate the capability of the model. The farm chosen was a 640-acre grain corn operation. A printout of the input information provided to the program and the output from the program is shown in **figures** 2 through 5. In these figures, the underlined numbers indicate the information which is supplied by the operator during program execution. The information requested by the first part of the program is shown in **figure 2.** The first information requested is the work days/week, work hours/day, scheduling efficiency, reliablity, and the number of machines. Scheduling efficiency indicates the % of the working hours each day which

Table 1. Assumed field machine data

Machine	Id	Min size	Incr	Max size	Slow speed (mph)	Fast speed (mph)	Tot repair (% ist cst)	Life (hrs)	Eff	Energy	
Plow	1	2*	1	8	2.5	4.5	120	1,500	.8	10	LBS/IN*2
Fertilizer	2	50**	10	50	2.0	6.0	100	2,500	.8	80	LBS/FT
Disc harrow	3	6**	1	30	3.0	6.0	120	2,000	.9	250	LBS/FT
Harrow	4	8**	1	30	3.5	6.0	120	2,500	.9	150	LBS/FT
Rotovator	5	5**	1	15	1.0	5.0	120	1,500	.8	20	HP-HR/ACRE
Planter	6	2***	2	12	3.0	6.0	100	1,200	.65	400	LBS/ROW
Graindrill	7	8**	2	16	2.5	5.5	100	1,000	.7	105	LBS/ F T
Cultivator	8	2***	2	8	1.0	5.7	100	2,000	.8	250	LBS/ROW
Chopper	10	2***	1	2	.5	4.5	80	1,500	.67	1.5	HP-HR/TON
Stalkcut	11	3**	1	15	1.0	6.0	80	1,500	.825	3	HP-HR/FT/MPH
Combine	14	2***	1	8	1.0	4.0	120	1,200	.67	.13	HP-HR/BU
Windrow	16	10**	2	16	3.3	5.4	120	1,500	.8	300	LBS/FT

* Plow sizes are given in number of 16 inch bottoms
** Machines with width specified in feet
*** Machines with width specified in rows

the machine is actually working in the field. Implement preparation, travel and down time are the contributing factors in decreasing the scheduling efficiency. Reliablity is a factor between 0 and 1. High values of reliability indicate good maintenance and servicing programs as well as superior operator competence. A lack of these conditions would be reflected in lower reliability. The computer program persently has information concerning 12 different machines stored within it. This has the potential of being increased to a total of 16 machines. The information for each machine required by the model is shown in **table 1.** The program is organized so that identification numbers 1 through 13 are reserved for tractor drawn machines and identification numbers 14, 15 and 16 are reserved for self-propelled machines.

The second piece of information requested by the model is the number of subsets. The program will handle a maximum of ten subsets of operations. For each subset the computer requests the day and month on which the operations in the subset can begin, the day and month by wich all operations in the subset must be completed, the percent of these days during which field operations can be performed and the number of field operations in the subset. In the example, the first subset is land preparation and planting. Operations in the subset begin after April 17 and must be completed before May 25. The percent of usable days is 39.4 and there are 4 operations in the subset.

The model next requests for each operation, the operation identification number, which is indicated in **table** 1 and the acreage on which each operation must be performed. In the example, 480 acres must be plowed in the spring and 640 acres must be disked, harrowed and planted within the time provided in the subset.

Subset 2 provides for two cultivations of the crop. Subset 3 is combine harvesting of all 640 acres. One requirement of the program is that self-propelled operations be placed in sets by themselves. The reason for this is that tractor horsepower requirements are based only upon those operations in which tractors are used. To prevent the horsepower required by self-propelled machines from begin included in tractor horsepower determinations, they must be placed in separate subsets.

Subset 4 of the example is stalk chopping of all of the corn acreage and fall plowing of 160 acres. The next information requested by the program concerns additional input information for several of the operations. Plowing depth in inches is required for subsets in which there is plowing. Row width in feet is required for row crop machines. Rolling resistance and yield in bushel per acre is required for combine operations.

Based upon the above information, the energy, hours and horse-

Figure 3. Horsepower requirement determination and tractor assignment to operations.

Set 3	date 25/9	to 24/10	percent usable	days=69.4
operation	energy	hours	horsepower	acres
14	28370.1	153.3	184.9	640.0
Total	28370.1	153.3		

Set 4	date 25/10	to 14/12	percent usable	days=12.8
operation	energy	hours	horsepower	acres
11	7680.0	30.8	248.6	640.0
1	4224.4	16.9	248.6	160.0
Total	11904.4	47.8		

Total energy=66192.78

Horsepower to be purchased=332

For tractor assignments key '<u>continue execute</u>'

Tractor and machinery selection: tractor sizing and assignment to operations

Tr max hp, tr min hp, hp incr? <u>120,30,1</u>

Tractor assignment for set 1
tr no=1 energy (hp-hr)=9062.9 tr hp=120
tr no=2 energy (hp-hr)=9062.9 tr hp=120
tr no=3 energy (hp-hr)=4271.9 tr hp= 92

Tractor assignment for set 2
tr no=3 energy (hp-hr)=3520.3 tr hp= 92

Tractor assignment for set 4
tr no=1 energy (hp-hr)=4308.4 tr hp=120
tr no=2 energy (hp-hr)=4308.4 tr hp=120
tr no=3 energy (hp-hr)=3287.4 tr hp= 92

Tractor	and machine	schedule for set 1
tractor	operation	acres
1	1	343.2
2	1	136.7
2	3	640.0
2	4	420.2
3	4	219.7
3	6	640.0

Tractor	and machine	schedule for set 2
tractor	operation	acres
3	8	1280.0

Tractor	and machine	schedule for set 3
tractor	operation	acres
0	14	640.0

Tractor	and machine	schedule for set 4
tractor	operation	acres
1	11	359.0
2	11	280.9
2	1	35.4
3	1	124.5

1 =different tractor size, 2 =machinery selection? 2

Tractor and machinery selection; Machinery selection power required to complete each of the operations is calculated and printed out by the computer. The horsepower to be purchased is then determined based upon the largest horsepower required by any one subset. In the example, subset number 4 required the largest amount of power, 248.6 hp. Horsepower to be purchased was calculated from this value and was found to be 332 horsepower.

Analysis of the subsets of cropping operations at this point in the program can identify bottlenecks in the farming operations and can provide insight into methods of alleviating them. For example, by shifting some of the land to be plowed in the fall, subset 4, into the spring, subset 1, total horsepower could be reduced. If it appears desirable, this portion of the program can be rerun to determine the effect of changing input values. When the operator has determined what he believes is an adequate schedule for crop production operations, he can load the second part of the program which is tractor sizing and assignment to operations.

The only information requested by the computer to size and assign tractors is the maximum tractor horsepower, the minimum tractor horsepower and the horsepower increment. In the example, the maximum tractor horsepower, as shown in **figure 3**, was 120 horsepower, the minimum was 30 horsepower and a 1 horsepower increment between these two limits was chosen. The program determined that three tractors were required, two tractors with 120 hp and one tractor with 92 hp. All three tractors were needed in both subset 1 and subset 4 while only the 92 horsepower tractor was needed in subset 2. Note that subset 3 is not shown since to tractors were used in this subset.

Next, the program assigns tractors to individual crop operations. In subset 1 of the example, tractor 1 is used for plowing while tractor 2 is used for plowing, disking and harrowing. Tractor 3 is used for some harrowing and this tractor does all the planting. In subset 2, only tractor 3 is used, while in subset 4 all of the tractors are again required. In subset 4, tractor 1 and 2 are used for stalk chopping and tractor 2 and 3 for plowing.

At this point, the tractor sizing and operation assignment portion of the program can be return if it appears desirable to change the tractor horsepower limits. If the operator is satisfied with the tractor selection, he can initiate operation of the machinery selection portion of the program.

The machinery selection portion of the program does not print any results. Therefore, when machinery selection is complete the computer automatically loads and executes the cost analysis portion of the program.

Annual use and costs of operating each of the tractors and

Figure 4. Machinery use and costing for tractor drawn machines.

```
Tractor and machinery selection: use and cost
Int, tax, ins, and housing rates as a % of fixed cost? 7.5, 0,.8, 2
Price of machine type 1 which is 8.0ft • wide? 1800
Annual cost and use for machine 1 of type 1
Acres=378.7  time=111.1hrs  energy=9999.9hp-hr
  size=8.0 to 10.6 ft •  size selected=8.0ft •
price=$1800.00  service life=10.0yr  dep=$162.00/yr
int=$60.75/yr  housing=$32.40/yr  tax=$0.00/yr
ins=$12.96/yr  repair=$143.99/yr  tot cost=$412.10/yr
Price of machine type 1 which is 8.0oft • wide? 1800
Annual cost and use for machine 2 of type 1
acres=261.2  time=87.7hrs  energy=6897.7hp-hr
  size=8.0 to 10.6 ft •  size selected=8.0ft.
price=$1800.00  service life=10.0yr  dep=$162.00/yr
int=$60.75/yr  housing=$32.40/yr tax=$0.00/yr
ins=$12.96/yr  repair=$113.73/yr  tot cost=$381.84/yr
Price of machine type 3 which is 23.0ft • wide? 2500
Annual cost and use for machine 1 of type 3
acres=640.0  time=43.4hrs  energy=3911.5hp-hr
  size=23.0 to 30.0 ft •  size selected=23.0ft •
price=$2500.00  service life=10.0yr  dep=$225.00/yr
int=$84.37/yr  housing=$45.00/yr  tax=$0.00/yr
ins=$18.00/yr  repair=$58.67/yr  tot cost=$431.04/yr
Price of machine type 4 which is 30.0ft • wide? 1400
Annual cost and use for machine 1 of type 4
acres=640.0  time=28.8hrs  energy=2346.9hp-hr
  size=30.0 to 30.0ft •  size selected=30.0ft •
price=$1400.00  service life=10.0yr  dep=$126.00/yr
int=$47.25/yr  housing=$25.20/yr  tax=$0.00/yr
ins=$10.08/yr  repair=$17.41/yr  tot cost=$225.94/yr
Price of machine type 6 which is 30.0ft • wide? 2500
Annual cost and use for Machine 1 of type 6
acres=640.0  time=50.2hrs  energy=3466.1hp-hr
  size=30.0 to 30.0ft •  size selected=30.0ft •
price=$2500.00  service life=10.0yr  dep=$225.00/yr
int=$84.37/yr  housing=$45.00/yr  tax=$0.00/yr
ins=$18.00/yr  repair=$94.19/yr  tot cost=$466.56/yr
Price of machine type 8 which is 20.0ft • wide? 1750
Annual cost and use for machine 1 of type 8
acres=1280.0  time=51.0hrs  energy=3520.3hp-hr
  size=20.0 to 20.0ft •  size selected=20.0ft •
price=$1750.00  service life=10.0yr  dep=$157.50/yr
int=$59.06/yr  housing=$31.50/yr  tax=$0.00/yr
ins=$12.60/yr  repair=$40.17/yr  tot cost=$300.84/yr
Price of machine type 11 which is 13.0ft • wide? 1700
Annual cost and use for Machine 1 of type 11
acres=359.0  time=47.8hrs  energy=4308.4hp-hr
  size=13.0 to 15.0ft •  size selected=13.0ft •
price=$1700.00  service life=10.0yr  dep=$153.00/yr
int=$57.37/yr  housing=$30.60/yr  tax=$0.00/yr
ins=$12.24/yr  repair=$39.06/yr  tot cost=$292.27/yr
```

machines is determined by the fourth part of the program. The first information requested by the use and cost portion of the program is annual interest, tax, insurance and housing rates as a percent of the fixed cost of the machine (see **figure** 4). Fixed cost is calcualted by the program as the initial cost less the salvage value for each machine.

In calculating annual use, the model accumulates the work performed by an individual machine in all of the subsets in which it is used. In the example, two plows were required and used in both subset 1 and subset 4. The total work performed during the year by each plow was thus the sum of the work performed in both subsets. It whould be noted that in set 1 the second plow was used on tractor 2 while in set 4 it was used on tractor 3. The model checks the compatibility of machines to tractors. In this case the same plow could be used on both a 120 hp tractor and a 92 hp tractor. Had this not been the case, a third plow would have been required for the smaller tractors.

Other tractor drawn equipment required by the farming operation of the example included one 23-foot wide disc, a 30-foot harrow, a 30-foot planter, a 20-foot cultivator and two 13-foot stalk cutters. It should be noted that the model selects the smallest machine size which can meet the constraints on completing a set of operations within the specified time. The model does not necessarily match widths of machines such as planters and cultivators. Thus, the model chose a 30-foot planter and a 20-foot cultivator. In actual practice, the same planter and cultivator widths would usually be purchased. When annual costs of operation of all of the tractor drawn machines is complete the total for these machines is determined.

The program next calculates the use and cost of operation of the self-propelled machines (see **figure** 5). In the example, the only self-propelled machine is a 15-foot, 6-row corn combine. Since a 12-row planter was used, these two machines are compatible. The combine is the only machine in the example with an estimated life of less than 10 years. The life expectancy of the combine based upon an annual use of 153.3 hours is 7.8 years.

Tractor costs of operation are next calculated and totals given. Finally, annual cost from tractors, tractor drawn equipment and self-propelled machines are summed together. In the example, $70,150 in initial investment in equipment was required and the annual fixed cost of owning and operating the equipment was estimated to be $14,577.11/year.

Labor used in the actual field operations and fuel consumption are the last values printed out by the program. Given the wage rate and fossil fuel cost per gallon, the total operating cost of the equipment can be calculated.

Figure 5. Machinery use and costing for tractor drawn machines, self-propelled machines and tractors.

```
Price of machine type 11 which is 13.0ft • wide? 1700
Annual cost and use for machine 2 of type 11
acres=280.9  time=37.4hrs  energy=3371.5hp-hr
  size=13.0 to 15.0ft •   size selected=13.0ft •
price=$1700.00  service life=10.0yr  dep=$153.00/yr
int=$57.37/yr  housing=$30.60/yr  tax=$0.00/yr
ins=$12.24/yr  repair=$30.56/yr  tot cost=$283.78/yr
Totals for all tractor drawn machines
price=$15150.00  service life=0.0yr  dep=$1363.50/yr
int=$511.31/yr  housing=$272.70/yr  tax=$0.00yr
ins=$109.08/yr  repair=$537.82/yr  tot cost=$2794.41/yr
Price of machine type 14 which is 15.0ft • wide? 19000
Annual cost and use for machine 1 of type 14
acres=640.0  time=153.3hrs  energy=28370.1hp-hr
  size=15.0 to 20.0ft •   size selected=15.0ft •
price=$19000.00  service life=7.8yr  dep=$2185.57/yr
int=$641.25/yr  housing=$342.00/yr  tax=$0.00/yr
ins=$136.80/yr  repair=$2622.69/yr  tot cost=$5928.32/yr
Totals for all self-propelled machines
price=$19000.00  service life=0.0yr  dep=$2185.57/yr
int=$641.25/yr  housing=$342.00/yr  tax=$0.00/yr
ins=$136.80/yr  repair=$2622.69/yr  tot cost=$5928.32/yr
Price of 120hp tractor=? 13000
Tractor num 1  power=120db-hp  use=148.5hr
price=$13000.00  service life=10.0yr  dep=$1170.00/yr
int=$438.75/yr  housing=$234.00/yr  tax=$0.00/yr
ins=$93.60/yr  repair=$173.82/yr  tot cost=$2110.17/yr
Price of 120hp tractor=? 13000
Tractor num 2  power=120db-hp  use=148.5hr
price=$13000.00  service life=10.0yr  dep=$1170.00/yr
int=$438.75/yr  housing=$234.00/yr  tax=$0.00/yr
ins=$93.60/yr  repair=$173.82/yr  tot cost=$2110.17/yr
Price of 92hp tractor=? 10000
Tractor num 3  power=92db-hp  use=160.5hr
price=$10000.00  service life=10.0yr  dep=$900.00/yr
int=$337.50/yr  housing=$180.00/yr  tax=$0.00/yr
ins=$72.00/yr  repair=$144.51/yr  tot cost=$1634.01/yr
Total for all tractors
price=$36000.00  service life=0.0yr dep=$3240.00/yr
int=$1215.00/yr  housing=$648.00/yr  tax=$0.00/yr
ins=$259.20/yr  repair=$492.17/yr  tot cost=$5854.37/yr
Total annual cost
price=$70150.00  servicé life=0.0yr  dep=$6789.07/yr
int=$2367.56/yr  housing=$1262.70/yr  tax=$0.00/yr
ins=$505.08/yr  repair=$3652.69/yr  tot cost=$14577.11/yr
labor employed=611.0hrs/yr  fuel consumed=6619.2gal/yr
```

Attacking Salinity on Irrigated Lands

by. U.S. Department of Agriculture
(Agricultural Research,Dec.1974,Vol.23,No.6)

Using the word "excited" in referring to agricultural secientists may be treating semantics a little loosely but it closely describes researchers involved with irrigation and salinity management along the Colorado River Basin and elsewhere.

Entirely new concepts of increasing irrigation efficiency with the object of raising the quality and quantity of water available in the river basins are under study by ARS.

Field studies are being conducted at Grand Valley, Colo., and Tacna, Ariz., based on research coming out of the U.S. Salinity Laboratory, Riverside, Calif. At the Laboratory, ARS scientists found that in studies of crop response to salinity more emphasis should be placed on the salinity of the irrigation water rather than on the salinity of the soil water as in the past.

When crops are irrigated, plants take up some of the water, some is lost through evaporation, and some drains through the soil and goes back to the river or filters down to ground water.

All natural waters used for irrigation contain some salt. Evaporation and plant use concentrates the salt in the fraction of water left in the soil.

Since too much salt can cut yields of crops, traditional practice has been to leach these salt concentrations out of the field by putting on excessive amounts of water. The salts are moved down and are taken off in the drainage water, oftentimes returning to the river and creating problems for irrigators or other downstream users.

ARS plant physiologist, Leon Bernstein, in studies at the Salinity Laboratory, found that a crop—in this instance, alfalfa—gets most of its water from roots in the top portion of the

Fig.1. The ability of electrically driven sprinkler systems to deliver varying amounts of water makes them ideal for the ARS research being conducted in the Grand Vally to determine the effects of salinity on irrigation management along the Colorado River Basin and on other arid lands where irrigation is required (0874R1403-16).

Fig.2. Salt crystals in this soil sample show evidence of the problem farmers have to deal with in the Colorado River Basin and on many other irrigated lands (0874R1407-27).

soil profile. He also found that as long as the irrigation water is of good quality, the plants can tolerate much more salinity near the bottom of the root zone than had previously been believed.

Management, however, plays a key role because the irrigation water must be precisely applied. The water must penetrate the soil uniformly throughout the field. In operational terms, reducing the leaching fraction—the "excessive" amount over and above what is needed for plant use and evaporation—will result in a reduced quantity of salt discharged. The practice changes the composition of the discharged salt, and as much as 30 percent is

Fig.5. Mr. Fischbacher takes a salinity reading from the reservoir which feeds the sprinkler system. The 27-acre experimental plot is in the background (0874R1405-7).

Fig.3. Mr. Fischbacher checks soil moisture pressure using one of the many measuring devices scattered throughout the experimental plot (0874R1404-22).

precipitated into chemically inactive salts such as lime and gypsum. Dr. Bernstein says that at this point an equilibrium can be established that can be maintained over long periods of time.

With this in mind, ARS scientists in Colorado and Arizona are irrigating more often with less water, cutting the volume of water returning to the river or

Fig.4. Soil samples are taken frequently for comparison with readings from equipment buried in the test field. Biological technician Gordon Fischbacher takes a sample that will be analyzed for soil moisture, salinity, and CO_2 content (0874R1399-21A).

water table as drainage. By using this method, the researchers say a substantial amount of salt will be precipitated harmlessly in a lower part of the root zone, staying in the field and out of the river or ground water.

In Colorado, in cooperation with the Bureau of Reclamation,

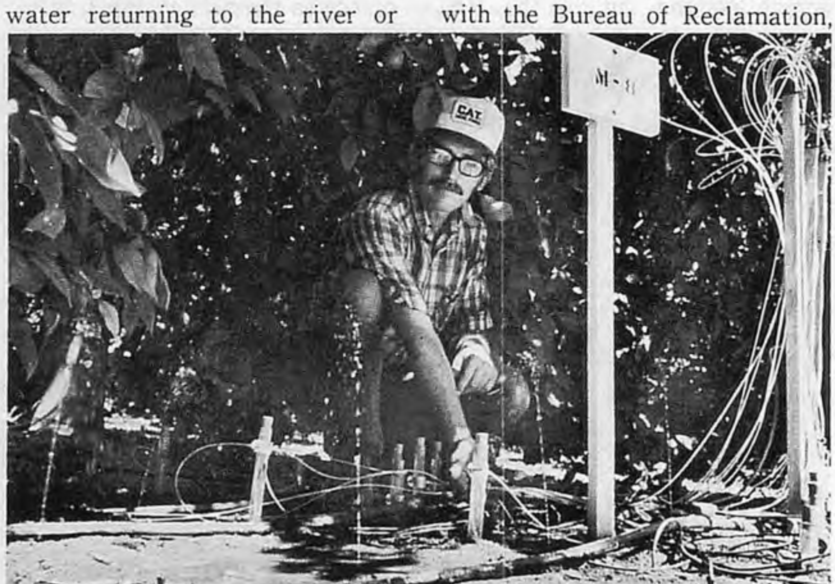

Fig.6. Chemist Robert Ingvalson inspects the drip system and tensiometers under a tree. While it is called drip, water actually squirts at 1-foot intervals from a tube coiled around the base of the test tree. The tensiometers measure soil-water suction at 15, 30, 45, and 60 centimeters (cm) beneath the trees. Other tensiometers set at 30 cm under the trees sense when a predetermined "dryness" is reached and activate the drip system for that particular test area (0874R1408-14).

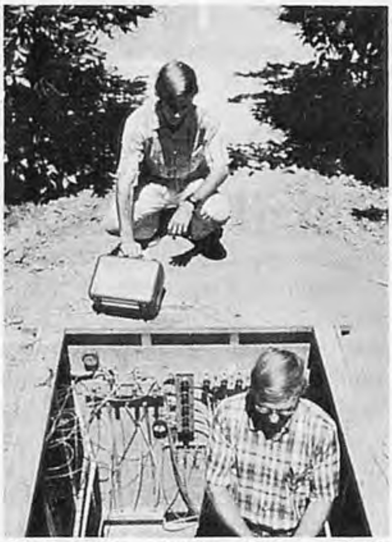

Fig.7. Soil scientist James Wood watches as Dr. Ingvalson examines vacuum regulators which collect moisture through tubes located at a 4-foot depth below the entire test area. The moisture is analyzed for volume and chemical content (0874R1407-34).

ARS has installed a 600-foot radius electric-dride pivot sprinkler that irrigates 27 acres of corn. The circular field is divided in six pie-shaped segments with two replications of three leaching fractions—. 05,. 10, and .15. Although full-scale evaluations began this year, tests last year were judged quite successful. Corn yields compared favorably with surrounding fields, water application rates and leaching fractions were about what was designed for the system, and preliminary data on salinity showed encouraging trends.

In Arizona, in cooperation with the Environmental Protection Agency, ARS scientists have set up projects for trickle irrigation of citrus and sprinkling alfalfa with a moving modified trickle system. Research on the citrus plots was started a year ago. Research on the alfalfa plots is beginning now.

Irrigation on the Arizona plots is controlled automatically by "querying" tensiometers on a regular time schedule. Salinity sensors relay information that is used to set tensiometers to maintain given salinity levels in the fields.

Fig.8. Dr. Ingvalson checks a control point which can be set to deliver different amounts of irrigation water to different areas while Dr. Wood takes a salinity reading from an underground sensor (0874R1409-30).

Jan van Schilfgaarde, Director of the Salinity Laboratory, said, "We can visualize an irrigation management system that, compared to conventional. practices, results in a reduced volume of water applied and a reduced quantity of salt discharged in a reduced drainage volume, while maintaining crop yields.

"In view of the increasing interest in water quality and the substantial impact of irrigation on the salt concentration in some of our Western rivers, such observations are particularly timely. They suggest that it is possible, by changes in irrigation management, to greatly reduce the amount of salt discharged from irrigation projects," Dr. van Schilfgaarde said.

"These observations also indicate, that, in some circumstances, it may be feasible to dispose of reduced amounts of highly concentrated drainage water by methods other than returning it to streams in order to take some of the salt out of the subsystem. Evaporation ponds or bypass channels may become feasible alternatives for alleviating salt pollution if the volume of drainage water is sufficiently small."

Fig.9. Lysimeters buried beneath the test plots check moisture use of the plants and underground water flow. Agricultural engineer Dennis Kincaid checks one of the three load cells that, despite being under 10 tons of soil, can detect a "heavy dew" (0874R1401-1).

The Ability of the Developing Countries to Meet Their Own Agricultural Needs in the 1980's ※

by
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Economic Research Service
U.S. Department of Agriculture

Debates over life's more important problems usually take place in an environment of ambiguity and confusion. For example, in the Washington Post on July 17, there appeared two news items related to the world's livestock situation. One item reported that the U.S. House of Representatives had voted to guarantee a large share of private loans made to livestock producers because of large losses they were experiencing due to low prices of meat animals. Another item said that the European Economic Community had decided to bar imports of beef because massive surpluses were accumulating. Both these actions were taken with a view that the price of meat was not high enough, which as economists we know is the result of demand being inadequate relative to supply.

In the same issue of the Post, on the editorial page, a columnist was soundly chastizing U.S. consumers for eating too much meat, thus pre-empting grain which might go to the starving poor in Calcutta.

Why should important issues nearly always be treated in such a confusing manner? Often there are clearly different interests involved, sometimes conflicting, and the promoters of conflicting interests may naturally disagree. But, I think the more general, and probably the more important reason is that most of life's important problems are in fact rather complicated. Because of intellectual laziness or the desire to find simple solutions to difficult problems, commentators fall into the pit of over-generalization and the easy substitution of moral indignation for knowledge and insight.

I will try to avoid adding to what have seemed to me to be some of the main sources of confusion and controversy about the world food situation ; failures to distinguish between time periods, between countries, between the different kinds of food problems (nutrition, balance-of-payments, impacts on employment and income distribution etc.)

There are many food problems in the world, rather than one world food problem. I shall make little reference to most of them. For example, I will give little attention to the extremely important problems of the distribution of food, either in their technical or socio-economic aspects. I will say very little about the problem of unemployment in the developing countries. I shall be talking mainly about the production of grains. I will try to stick largely to the time frame indicated in my title, that is to the 1980's, and, therefore, I will give little attention to the difficult current and short-run problems facing developing countries. While I will refer often to the developing countries as a group, I am aware of the very great differences among the developing countries with regard to their food problems and potentials.

Key point of the world food problems

Most of the current concern about the world food situation is focused on problems of the developing countries. Many are unsure whether the developing countries will be able to feed their growing populations from their own agricultural production,

※Speech given at the Canadian Agricultural Economics society/Agricultural Instisitute of Canada, Qebec City, Canada, August 6, 1974.

or whether they will become increasingly dependent on imported food which they will have difficulty financing.

These are real and important problems. I do not, of cource, imply that agricultural self-sufficiency is a desirable goal for all the less developed countries. For many of them such a policy is clearly unresonable. A good many developing countries are able and will become increasingly able to buy some food more cheaply than they could produce it at home. However, many others are unlikely to be able to pay for rapidly increasing food imports, and the prospects of increasing and long-continuing food aid are unattractive to both receiver and donor countries.

Most developing countries have the natural resources which can support great increases in agricultural production. However, the development and exploitation of this potential may take decades. Institutions must be built ; research must be undertaken ; large investments must be made ; and policies must be changed. If an adequate research thrust to develop more productive crcps and livestock suited to the conditions of the developing countries can be mounted, and if the investments and policies of the developing and developed countries can be directed to providing the necessary infrastructure, inputs, and incentives for the farmers in the developing countries, the agricultural production of those countries could be greatly increased by the late 1980's. This increased production could lessen their dependence upon imports of food from the developed countries. However, I believe the developing countries, as a group, will continue to need large imports of grain from the developed countries throughout most of the 1980's.

The uncertainty surrounding the future of world agriculture and trade is so great as to make it impossible to make entirely objective forecasts. However, my judgments are consistent with several comprehensive studies of the agricultural prospects of the developing countries as well as with the agricultural experience of those countries during the last 20 years.

Implicit in my analysis is the judgment that the events of the last 2 years do not indicate a fundamental shift in the world's ability to feed itself, and that the extraordinary decline in world food production in 1972 was primarily the result of weather patterns unlikely to be often repeated. The coincidence of this decline with an unprecedented series of events, including the energy crisis, the USSR's decision to import massive quantities of grain, and the devaluation of the dollar, brought about the so-called food crisis of the last 2 years. Some of these events will continue to affect the world food situation. The energy crisis, in particular, places heavy burden on many countries including many developing countries. The OPEC of course, are in a vastly improved economic position and certainly ought to be able to feed themselves or pay for food imports.

I have no particular insight into the possible great long-run changes in the world economy resulting from the new energy situation. If the cost of energy remains relatively high, comparative advantage should shift toward less energy-intensive agriculture. However, at present it is impossible to foresee future prices of fuel and fertilizer and their effects on world agriculture.

Despite many uncertainties in the future world food situation, I think predictions of mass starvation are overdrawn. Rather, it is more likely that diets for most of mankind will continue to improve, although slowly, and perhaps erratically. However, I want to emphasize that many difficult problems must be solved if deterioration in the world food situation is to be prevented. The food supply of many of the developing countries is precariously dependent on the weather and on aid from outside. Hundreds of millions are poorly nourished, and many are seriously threatened by food shortages. If the world ignores these problems, then unprecedented catastrophes could develop. I don't believe we will ignore the critical short-run problems. One reason is that the demand for food is so inelastic, that when faced with shortages, as in 1973 and 1974, it sends out very loud signals, to farmers, agri-business and governments that corrective action is needed. The signals of the high prices and shortages have been loud enough to gain a lot of attention. Unfortunately, policies impede the working of the price system and effective reactions in many countries. Also, there is great danger that when the present crisis subsides and prices fall, we will be lulled into thinking that the long-run problems are also solved.

The change for past 20 years

Per capita food availabilities have been improving rather steadily for some time. I believe most of the forces underlying this improvement will continue, and can be reinforced in the future.

What about the past trends? What was happening before the present food "crisis?" For at least 20 years, the following changes have been taking place :

1. Per capita real incomes have been increasing, even in most of the poor countries, permitting a slow improvement in diets. These improved diets have permitted dramatic increases in human longevity. The main causes of increased longevity have been improved medical and sanitation systems, but the

increases are additional evidence that diets have not deteriorated, despite unprecemented rates of population growth.

2. Per capita food production has been increasing slowly, in the developing countries as a group. According to our estimates, there have been upward trends in per capita food production in about half of the countries. In a number of other countries, food production has just about kept up with population.

3. Per capita grain consumption (taking account of trade as well as production) has been increasing in most developing countries. Since World War II, however, developing countries shifted from net exports to net imports of grain, which now supply about one-tenth of their total calories.

4. The number of deaths directly attributed to famines has apparently declined greatly. In this period, there have been no massive famines such as occurred in earlier times.

5. Land has been becoming relatively less important in agriculture as the use of other inputs grows. However, there is still much unused, agricultural land in the world. One estimate is that less than half the potential acreage is now cultivated.

6. Improving communications permit a more effective response to emerging famines. The improvement I have in mind is relative to the past. In Ethiopia, the existence of radio-telephones did not bring an effective local government response to sudden price increases indicating scarcities.

7. Improving transportation has permitted moving food more quickly and more cheaply to where it is needed. This improvement also is relative to the past. Although expensive, delivery by air has been used in the Sahel where transportation has been a very serious problem.

The future world food situation

What views of the future world food situation are available? The comprehensive projection studies to which I referred earlier have been done by three different organizations.

Both the Food and Agriculture Organization of the U.N. (FAO) and the Economic Research Service (ERS) of the USDA have prepared a number of long-run projections of world production, utilization, and trade of agricultural commodities. Iowa State University Press last year published similar projections.(1)

FAO recently completed a projection of trends in grain production and utilization by countries. The extrapolation of these trends would result in sizeable increases in grain needs in developing countries and surpluses in developed countries by 1985.(2) The Iowa State projections, which exclude consideration of the impact of the green revolution, suggest similar possibilities.

ERS projections to 1985 also suggest that the developed grain exporting countries will supply the less developed importing countries with increasing amounts of grain. Most of the developing countries will tend to import more wheat rather than feed grains because of limited foreign exchange and because their people can not afford much livestock products. However, some with abundant foreign exchange may show a rapid growth in feed grain imports.

The expected increase in grain imports has been called a food "gap" and implications have been drawn as to its unfortunate consequences, either in terms of the great burden on the balance of payments of the importing countries, or in terms of undesirable food aid programs. These concerns are appropriate. But, in evaluating them, we should keep in mind that in part the "gap" is the result of higher demand from expected increases in per capita incomes and food consumption in the developing countries, as well as population growth.

ERS is presently refining and revising its projections in connection with a study of the world food situation and prospects. We plan to publish it next month. One of our major problems in making projections is to make reasonable assumptions with respect to uncertainties arising from the energy crisis and changing policies of governments.

Green revolution in developing countries

Projection studies are in large degree based on extrapolations of trends. Let us look in a little more detail at the past agricultural performance of the developing countries. In these countries, cereals continue to play a dominant role in the food supply, but the developing countries did not perform nearly as impressively in the production of grains as did the developed countries in the 1950's and 1960's. The developing countries accounted for only about 40 percent of the world's increase in grain production in this period. In the latter part of the 1960's these countries accounted for only one-third of world grain production although their area in grains was slightly more than that of the developed countries.

However, agriculture was by no means stagnant in the developing countries. They increased grain area 35 percent, thereby overtaking the grain area in developed countries, which did not expand during this period. They increased grain yields 32 percent, to nearly equal the developed countries' 1948-52 yields, which increased 63 percent by 1966-70. They increased grain production 78 percent to a level nearly equal to the developed countries' 1948-52 production.

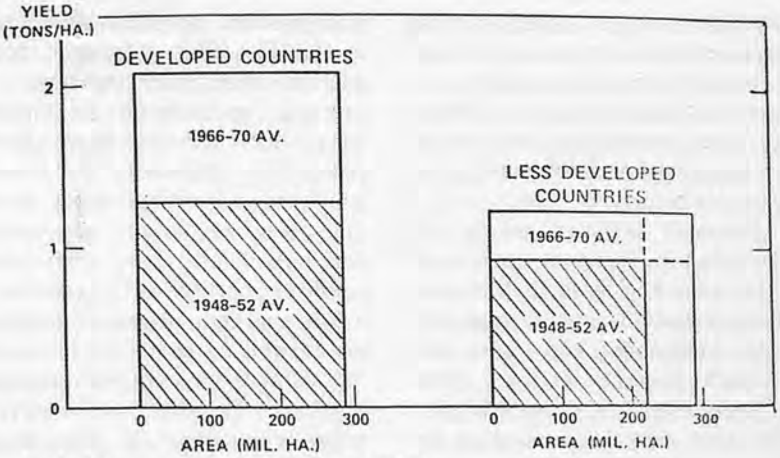

Fig.1. All grains : area, Yield and production
In this chart the area of each rectangle, determined as the product of the amount of land in grains (in million hectares or the horizontal axis) times yield per hectare (in kilograms on the vertical scale), represents the total production of grains in million tons for an indicated group of countries at a specified time. All four ractangles may be compared in height, in width, and in area.

This percentage increase in production exceeded that of the developed countries, which amounted to only 64 peccent.

Thus, about half of the increase in production in the developing countries was from increased area and about half from increased yields.

The green revolution was behind much of the increased yield of the developing countries. Although perhaps overpublicized, the green revolution has had important effects. Outside of Mexico, where the impact was first felt, the high-yielding varieties (HYV) of wheat and rice started to spread in the mid--1960's. In part of the Punjab area, farmers adopted the new wheat seed more rapidly that Iowa farmers adopted hybrid corn in the 1930's and 1940's. The HYV rate of adoption has been rapid in some areas, but, except for Mexico, they have been concentrated in Asia. By 1972/73, the HYV area occupied about a third of the wheat area and a fifth of the rice area in the non-Communist Asian developing countries. The HYV's represented a fourth or more of the total crop area in only a few countries in 1972/73:

—Wheat--Nepal, Pakistan, India, and Algeria.

—Rice--Philippines, Pakistan, Malaysia, and South Vietnam.

Thus, within Asia, the area was concentrated in only a few countries. India and West Pakistan together accounted for nearly 81 percent of the total HYV wheat area. Four countries (India, Philippines, Indinesia, and Bangladesh) accounted for about 83 percent of the total HYV rice area. India alone encompassed 61 percent of the wheat and 55 percent of the rice areas. While the green revolution in wheat and rice has spread very fast, it is heavily concentrated in a few countries and on the better land in only certain regions of these countries. Also the adopters have tended to be the larger, wealthier farmers in those regions. It is very important development, but most regions, and most farmers, of the developing world have not yet been significantly touched.

Even where the HYV's have been adopted we have no precise estimates of their contribution. There has been little study of yields at the farm level. Yields have gone up in the countries where the HYV's have been widely used, but traditional varieties would also have responded to some degree to the improved inputs. The limited evidence available suggests that the HYV's have had a significant impact on increasing total national output in the countries where they have been widely adopted. A rough analysis suggests that yield increases (not all of which can be attributed to the HYV's) accounted for the following proportions of the increase in production between 1960-63 and 1970-73 :

—Wheat--Pakistan 67 percent, India 60 percent.

—Rice--Philippines 99 percent, Pakistan 76 percent, India 75 percent, Indonesia 61 percent, and Malaysia 27 percent.

Present problems of green revolution

What about the present problems with the green revolution? Can't they be overcome? If the full potential of the new varieties is to be realized, they must be accompanied by adequate water control, fertilizer, and insect and disease controls. However, most farmers fail to adopt all of the recommended package of inputs and procedures. For example, in India by 1969, only 12 percent of the HYV farmers were fully following recommendations. Many farmers spend much less than recommended on fertilizer. This gives some increase in yields but lessens financial risks. A study of wheat farmers in one area of Pakistan revealed that about one-tenth of the farmers used no chemical nitrogen and most of the rest used about one-half of the minimum recommended level of nitrogen. Studies of rice farmers in the Philippines during one season indicated that only two-thirds of the farmers used commercial fertilizer, and, of these, only one-third used the recommended rate ; during another season only 60 percent used fertilizer. According to another estimate, in the Philippines, nitrogen was applied at less than half the recommended rate. Only one study (a group of rice farmers in Bangladesh) has found most of the farmers using fertilizer at near the recommended levels. Of course, it is possible that, under farm conditions, some of the recommended rates are not economic. In fact, one study concluded that 85 percent of the variation in fertilizer application observed in an analysis of national average fertilizer use per hectare in nine Asian countries was accounted for by the different price ratios of rice to fertilizer faced by their farmers.(3)

Much concern has been expressed about the possible negative effects of the current fertilizer shortage on the progress of the green revolution. Fertilizer consumption in the developing countries is relatively small and has been expanding only slowly. Levels of fertilizer use vary widely in the developing countries but generally they are well below those in the developed countries. In 1971/72, for instance, total fertilizer use in the non-communist developing countries was only 15 percent of that in the developed countries in terms of application per hectare of arable land. Within the developing countries, fertilizer use per hectare was highest in Latin America and lowest in Africa.

It is impossible to estimate precisely the impact of the fertilizer shortage on the HYV's. Yields are determined by many factors of which fertilizer is only one. We do not know how much of the fertilizer used for grains goes to HYV's, and how much goes for traditional varieties. As I have pointed out, several studies indicate that farmers who use fertilizer on HYV's usually apply much less than the recommended levels. The high response of the HYV's to fertilizer in test plots and the relatively low use of fertilizer on them by farmers thus far suggests that their potential is much higher than has been achieved. On the other hand, it is likely that decreased use of fertilizer would have less impact on farm production than would be suggested by just looking at test plot results.

Although ferilizer use in the IDC's is low, there are reasons to think that it is used inefficiently. Transportation and storage are often inadequate and losses may be high. Specific fertilizer needs of soils often are not well known. Fertilizer may be applied at the wrong time and/or in the wrong dose. Complementary cultural practices--such as weed control and water management practices--often are not well done. Development of slow-release forms of nitrogen such as sulfur-coated urea may provide a sharp boost in efficiency on crops such as rice. It is to be expected that much more can be accomplished in these areas.

There may be opportunities for reducing the HYV dependence on nitrogen fertilizers by combining the shorter-season HYV's with legumes in multiple-cropping systems. Other biological forms of fertilizer have potential, but need much more emphasis in research programs. To provide the technological base for more efficient use of chemical fertilizers, as well as to investigate organic and biological forms over the longer-run, U.S. Secretary of State Kissinger has recently proposed the establishment of an International Fertilizer Institute. There is a great need for more research to improve effectiveness of chimical fertilizers, especially in tropical agriculture and to develop new methods of producing fertilizers from non-petroleum resources.

A large share of fertilizer used in the developing countries is imported. In 1972, the non-communist developing countries imported about half their N and P, and nearly all their K. The proportion of imports in total supply was greatest in Africa and least in the Far East. Domestic production of fertilizer has been increasing sporadically in South Asia, but imports have been rising. The regions of the world which have benefited most from the green revolution, especially South Asia, are those where the fertilizer shortage is the greatest.

Current high prices of fertilizer, as well as problems in locating supplies have caused reduced purchases by some of the developing countries. Of the large developing countries, only Bangladesh reported an actual (slight) decrease in fertilizer consumption in 1973/74, compared to 1972/73. However, in 1973/74, several of the developing countries did not match the annual growth rate of consumption they had achieved during the last 5 years. India was able to increase consumption by only about 3 percent, compared to an average growth rate of 13.5 percent since 1967.

The current fertilizer shortage probably will temporarily slow the pace of the green revolution in some nations which rely heavily on imports. These, in terms of the HYV's, are principally in South Asia. However, it is doubtful that it will, as some accounts have suggested, result in an abandoment of the HYV's. As I pointed out earlier levels of fertilizer use on the HYV's are not high relative to potential use. Moreover, the HYV's generally do as well as traditional varieties in the absence of fertilizer. In addition, the HYV's characteristically show higher rates of response to limited applications of fertilizer than do the traditional varieties. Thus, a higher proportion of the limited fertilizer available may be used on the HYV's. The fertilizer shortage may slow, but it is unlikely to cause a halt or reversal of the growth of agricultural output in the developing countries.

In the short-run, fertilizer production is limited by existing plant capacity. Responding to current high prices and shortages, manufacturers are using available capacity at near maximum in the developed countries. Operating rates in the developing countries have also increased somewhat over last year. Additional improvement in their operating rates could provide the critical margin between shortage and adequate supplies.

Plans to expand nitrogen fertilizer production capacity have been announced recently. If all the planned new plants should be built, and they and existing plants operated at high levels, more than adequate nitrogen supplies would be available in the late 1970's. However, a slight reduction in operating rates would forestall the kind of overcapacity situation which developed in the late 1960's. By the early 1980's still more capacity would be needed to meet projected demands.

Of- course, how much of the planned new capacity will finally come on line, and when, are unknown. Delays in construction are common, especially in the developing countries. The world's total supply of engineering talent and manufacturing capacity for essential parts is limited, and in response to high oil prices, the petroleum industry is placing heavy demands on the supply of engineers and parts.

Shortages of chemical pesticides may also be a temporary restraint on the green revolution. Increases in demand have led to higher pesticide prices. The developing countries are almost completely dependent on imports of pesticide chemicals. Hence, for this input they are in an even more vulnerable position than in the case of fertilizer, although pesticides are not as widely used as are fertilizers. The developing countries may face a particularly difficult problem getting pesticides during the 1974/75 season. Of course, there are undoubtedly many opportunities to increase the efficiency of use of pesticides in the developing countries. They are new to many farmers and probably are often used at the wrong time and in the wrong amounts. Also research may produce new ways of applying chemicals. For instance, the International Rice Research Institute recently developed a way of replacing insecticide sprays with an application of granular insecticide in paddy water at the root zone. This insecticide is more effective than sprays because it acts as a systemic; and one application is sufficient. Research attention may also be directed more toward developing disease and insect resistant varieties.

The green revolution in wheat and rice has made a significant contribution to the food supply of the developing nations and will undoubtedly continue to do so where economic conditions are favorable and necessary inputs are available. The current problems with these associated inputs make the task more complicated. And it was already complicated. But a large untapped yield potential still resides in the seeds already developed.

Agricultural output in developing countries

The experience of the last 20 years in increasing agricultural output in developing countries provides a soild basis for hope in the future. What must be done to increase agricultural output in the developing countries at a faster pace? The green revolution must be expanded on a number of fronts. Greater efforts must be made to reach the poorer farmers. The geographic and crop coverage must also be extended. Some of the present HYV's can HYV's can probably be adapted for use in areas not yet reached, but research on improved varieties of other crops, such as millet and sorghum, must be accelerated.

That many of the developing countries still have much more land which could be put in crops must be kept in mind. However, it is clear that these countries must soon start to move more vigorously to increase output per acre. This will require research, investments, and the development of infrastructure, including credit institutions, transportation, etc. It will also require policies designed to provide incentives to producers rather than the disincentives which have been all too common in the developing countries.

The high grain yields and other gains in agricultural productivity of the developed countries have been attained on the basis of technology developed in considerable part by major public expenditures on research. The research underlying the green revolution has in part been supported by private philanthropy. The green revolution has made it clear that agricultural research can have a very high payoff in the developing countries, as it often has had in the developed countries. By far the greater part of the agricultural research supported by governments is devoted to the agricultural problems of the developed countries rather than to those of the developing countries. One estimate indicates that a little more than one-tenth of the world's public expenditures on agricultural research in 1965 was spent in the developing countries (excluding the People's Republic of China).(4) Developing countries will not be able to build efficient and productive agricultural sectors unless the agricultural research efforts of those countries are increased many times over present levels. These research efforts can be augmented, but not replaced by international research centers and by increased research efforts by the

Farm mechanization helps develop the developing countries

developed countries directed toward, and possibly carried out in, developing countries.

One of the most encouraging lessons of the green revolution is that farmers in the developing countries, when properly guided, and when inputs and incentives are present, are capable of using modern technology. Fortunately, it is not necessary to achieve a massive transformation of values before agricultural progress can be made in the developing countries. Their farmers have demonstrated a willingness and ability to accept new ideas and to put them to use, even at considerable risk.

The green revolution has also demonstrated that at least some governments of the developing countries, in cooperation with aid from other countries and from international agencies, can marshal the infrastructure, the inputs, the extension programs and the policies necessary to achieve rapid agricultural progress. This is the most difficult problem of all. The human needs for more food are evident. The world has the basic resources needed. The principles of agricultural development are well established. But the political will and administrative skills are often lacking. The administrative skills can be developed. If the will to achieve agricultural progress is strong enough, especially among the government leaders who make or guide policies, then rapid progress is possible.

FAO's Indicative World Plan (IWP) published in 1969, involved the most comprehensive study yet made of the physical, economic, and social possibilities for increasing agricultural output. It specified growth objectives to 1985 intended to be consistent with the possibilities and with the projected growth in demand for food in the developing countries (about 3.9 percent, of which two-thirds was to be due to population, and one-third to growth in per capita income). During 1962 to 1971 the proposed growth rates were achieved in only a third of the developing countries. This was due to sluggish improvement in yields. Expanded acreage exceeded the targets. However, FAO has said that the IWP's production objectives can still be met, but with a time lag. The time lag will depend on policy decisions.

It world be uneconomical and undesirable for all developing countries to undertake programs for self-sufficiency in food. This easily voiced goal has had considerable appeal in developing countries, but it can be elusive and costly. Comparative advantage will dictate that some countries can better obtain some of their food needs by producing other products; then exporting them and importing food. Both the developed and developing countries could assist this process by reducing their barriers to imports. A recent FAO[5] study has made more precise estimates of what already well-known in general--the agricultural and trade policies in the developed countries involve important barriers to exports of some agricultural as well as industrial exports from the developing countries. Reduction of these barriers could provide opportunities and incentives for the developing countries to increase agricultural production where economic or to produce and export industrial products to pay for imported food where that would be more efficient.

During this decade, and part or perhaps all of the 1980's it is very likely that there will be some need for food aid in the developing countries, especially those hit with unusual weather or other natural calamities. However, it is unlikely that food aid will be available in the amounts that existed in the past. The United

States and other countries are unlikely to produce the surpluses which permitted the large amounts of past food aid. Although the food aid of the past was often used in ways very beneficial to the recipients, there is little doubt that, in some cases, it had negative impacts on the incentives to increase agricultural production in the receiving countries. In the absence of surpluses, the alternative of increasing production in the developing countries will nearly always be perferable to that of large and continuing amounts of food aid.

Conclusion

I believe that in the early 1980's and perhaps during the entire decade the developing countries as a group will continue to need large amounts of grain imports. However, the long-run continued growth of such imports would probably be economically undesirable for the developing countries and long-term massive food aid would be unwise for both givers and receivers. The feasible alternative is to enhance the agricultural productivity of the developing countries. There is every reason to believe that this can be done, but assistance will be required, both technical and financial from the developed countries. Adjustments in the trade and aid policies of the developed countries will also help.

The precise extent and timing of these change is one factor making an uncertain future for farmers in the United States and Canada. The future is always uncertain, but I think the probles of how to reduce, or insure against, the new uncertainties and risks facing farmers, agri-business, taxpayers and consumers in the developed countries will be important policy issues in the coming months. At the same time we cannot ignore the suffering of the world's hungry people.

REFERENCES

(1) Leroy L. Blakeslee, Earl O. Heady, and Charles F. Framingham, World Food Production, Demand and Trade, Iowa State University Press, Ames, Iowa, 1973.

(2) U.N., World Food Conference. Preliminary Assessment of the World Food Situation.

(3) Falcon, Walter P., and Timmer, C. Peter, The Political Economy of Rice Production and Trade in Asia, Food Research Institute, Stanford University, Stanford, California.

(4) Evenson, Robert and Kisler, Yoan, "Investment in agricultural Research and Extension : A Survey of International Data", Economic Growth Center, Yale University, Center Discussion Paper No. 121.

(5) FAO Agricultural Protection: Domestic Policy and International Trade; C 73/LIM/9, November 1973.

(Continued from Page 44)

control orders:

Import and export policies, taxes and levies, freight rates, insurance, safety, policy matters.

(5)Labour problems

(6)Logistice:

Training and services.

To accelerate the progress of the agricultural machinery industry, it is recommended that institutions like the Farm and Industrial Equipment Institute and the Indian Society of Agricultural Engineers are established in developing countries. UNIDO should assist in setting up such institutions on a national as well as regional basis. Effective liaison is required with the government, the financing institutions, the academy, the users and other professional groups and/or voluntary organizations.

The modern agricultural machinery industry in developing countries in Asia and the Far East is young and requires to be carefully developed. It is a 'growth' oriented industry, with potential for creating vest employment opportunities, improving productivity per worker and per hectare, removing the drudgery from herd farm work and raising the standards of living of the people.

PREFERENCES

1. 'Assessment of demand for inputs of farm mechanization', a report by the Indian Society of Agricultural Engineers, Oct., 1967.
2. International Directory of Agricultural Engineering Institutions, Food and Agricultural Organization of the United Nations, Rome, Italy, Nov. 1968.
3. Report of the United Nations ECAFE/AIDC-UNIDO Fact Finding Team on Industries Manufacturing Agricultural Machinery, ID/WG40/11, 1969.
4. The UNIDO report on the Export Group Meeting on Agricultural Machinery Industry in developing countries, ID/47, 1969.
5. The Green Book, an annual directory, Norman Kark Publications, London, U.K. 1970.
6. Report of the Panel for Tractors, the Development Council for Automobiles and Allied Industries, Jen. 16, 1970.
7. 'Bottlenecks in the farm equipment industry', a report by the Indian Society of Agricultural Engineers, Feb. 16, 1970.
8. 'Production of Agricultural Machinery in India', by B.K.S. Jain, a paper presented at the International Rice Research Conference, Manils, Philippines, April 21, 1971.
9. 'Role of UNIDO in the promotion of agricultural machinery and implements industry in the developing countries,' by A.A. Swamy Rao, April 1972.
10. Agricultural Mechanization in Asia, Vol. 3 No. 2, Farm Machinery Industrial Research Corporetion, Tokyo, Japan, 1972.

Farm Mechanization in Developing Countries

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Introduction

The importance of farm mechanization to increase production and to improve quality of farm produce is very well recognized in the agriculture of developed countries but the role of mechanization in developing countries, on the other hand, is very often questioned and looked upon with scepticism. Failures of mechanized schemes in various parts of the developing world have been many and have created lots of adverse feelings against mechanization.

It is a wide-spread opinion that due to scarcity of capital and know-how on the one hand and abundance of low-cost labour on the other hand, mechanization can only rarely be justified in the majority of developing countries.

Definition of Agricultural Engineering and Farm Mechanization

Too often the discussion on farm mechanization is limited to the introduction and use of tractors only, but the term meceanization certainly has much wider sense. FAO has adopted the following definition for Agricultural Engineering and Farm Mechanization:

"Agricultural Engineering is a field of engineering in which physical and biological sciences are utilized to find and apply better ways for the production, handling, processing and storing of food, fibre and fodder to improve rural life and living conditions."

Farm mechanization also refers to design, development, testing, manufacturing, marketing, operation and maintenance and repair of all agricultural tools, implements, machines and equipment. Appropriate selective mechanization of course has to be developed with respect to prevailing economical, human and social constraints.

Level of Farm Mechanization

Applying the definition, it become obvious that on nearly every farm in the world there is some form of mechanization. We can however differentiate three levels of technology:

1. Hand tool technology—the main source of power is human labour.
2. Animal draught technology—the main source of power is animals.
3. Mechanical power technology—power is mainly supplied by combustion engines and/or electrical motors.

In many cases the three levels exsist side by side.

Increased use of inputs such as fertilizers, chemicals, improved seeds and irrigation water, is widely recommended in developing countries. The opinion about farm mechanization as an input in developing countries differs greatly. However the problem to discuss is how to mechanize. For every given situation there is a justified level of technology which, if properly introduced, could increase food production and provide better living conditions for the farming population.

The Need for Improved Mechanization

The nature of biological processes, instable climatic conditions, sudden outbreaks of pest infestation, as well as the maturing of a crop in a short period of time, require timeliness, speed and accuracy of operations ensure maximum yields. This is especially true with the introduction of new, more sensitive varieties. At the same time it is well known that due to the nature of biological processes, beyond a certain level additional inputs do not lead to higher production levels.

For instance in the USA, some Eurpean countries, and Japan, the number of tractors has reached the upper level and in the USA the number has even decreased in the past decade although horsepower per unit has increased.

Availability of Power to Farmers in Various Parts of The World

More than half of the cultivated area of the world is still tilled by hand tools and animal draught equipment. The total number of 4-wheel tractors and crawler tractors used in world agriculture in 1970 is estimated at around 15.6 million of which 14.3 million are estimated to be in use in the USA, Canada, Europe (including USSR), Australia, New Zealand, South Africa and Japan. Only 1.3 million are estimated to be in use in the rest of the world.

Constraints and Possibilities by The Introduction of Farm Mechanization

Farmers and governments in many developing countries are facing difficulties in determining the appropriate level of mechanization and in selecting the most suitable type of equipment and machinery as well as determing required supporting services such as workshops, training of farmers, operators and mechanics, for their changing economy. A too rapid introduction of mechanical power and mechanization without proper planning, has frequently led to failures in the past. This applies especially to large mechanization schemes and bulk sales of farm equipment which are unfortunately still practiced by certain private and government suppliers. In these cases no or insufficient attention is given to the necessary supporting services such as training, after-sales services, etc.

Animal power will remain for years to come a most important aspect in agriculture in many countries and research for improved bullock implements should have a high priority. Local manufacture of bettbrhand tools, improved animal ploughs, seeding and planting equipment, ridgers, hand sprayers and small threshers, deserves major attention.

Before introducing a higher level of mechanization, detailed planning is required. A more advanced technique generally demands fundmental changes in farming and the success of applying new techniques depends on a number of factors which have to be taken into account. These aspects are of an economic, technical and social nature.

In the land-abudant of Africa, the Near East, and Latin America, additional power could enable the farmer to extend the area under cultivation through land development and timely preparation of the soil.

In the thickly populated areas of Asia and the Far East and in those countries where land and water is scarce, farm mechanization can contribute to intensifying the farming pattern in conjunction with other inputs. Timely tillage, seeding and harvesting leads directly to an increase in yields but also makes double and triple cropping possible. In Table 1 an illustration is given of the estimated yearly tractor manufacturing capacity. In Table II and illustration is given of manufacturing requirements for 4-wheel tractors in the future. The figures are based also on development trends in the past.

Table 1. 4-wheel tractor yearly manufacturing capacity estimates based on FAO Yearbook, FAO Trade Yearbook 1971 and information obtained from various sources*

North America	300,000
USSR	200,000
United Kingdom	150,000
Federal Republic of Germany	75,000
France	60,000
Italy	50,000
Rest of Western Europe	75,000
Eastern Europe, excluding USSR	100,000
Asia including the Near East	100,000
South and Central America	75,000
	1,185,000

*Estimates in actual production vary greatly, and only serve to provide an order of magnitude.

Mechanization and Employment

The question of how the level of technology affects the employment situation and the rural sector is an extremely complex one and it should not be looked at in isolation. All other aspects of mecenization have to be considered at the same time. An Expert Panel Meeting on the Effect of Farm Mechanization and Employment is scheduled for February 1975 in Rome. A limited number of leading engineers, economists and government planners will be invited to attend and to contribute in their personal capacity.

The objectives of the meeting are:

1. To provide assistance in determining mechanization policies in specific circumstances. It would require the identification of the main factors influencing the production per unit of land and per unit of labour. It should take into consideration effects on return of capital, total income distribution, forward and backward linked employment, institutions serving agriculture, foreign exchange, etc.
2. To decide how far these factors must be covered in further research.

The long-term objectives would be to prepare guidelines for the decision-making process for a national policy with respect to farm mechanization. The outcome would also be helpful to

Table 2. 4-wheel tractors in use in agriculture (FAO Yearbook 1971) and estimated development

	Tractor park in 000 1970	Growth rate 1961-1970	Manufact* requirement in 000 1970	Estimated growth rate 1970-1990	Tractor park in 000 1990	Estimated** manufacturing requirement by 1990 in 000
Europe, including USSR	8,073	7	800	1.6	11,064	1,062
North and Central America	5,402	0.3	280	0	5,402	449
Oceania	434	3.1	25	2	645	64
South America	577	6.7	60	7	2,232	334
Africa	344	7.2	40	7	1,330	199
Near East	201	13.8	30	10	1,351	243
Far East	585	21***	90	10	3,939	709
Total World	15,616	4.6	1,325		25,963	3,070
Total Europe, USA, Canada, New Zealand, Australia, South Africa, Japan	14,252					
Total rest of world	1,364					

* Including 5-10% for replacement
** Including 8% for replacement
*** Mainly in Japan

define FAO's policy and role with respect to farm mechanization.

Farm Mechanization and The Energy Crisis

The energy based on fossil sources required for production and operation of farm machinery in the world is around 2.4% of the world's yearly energy requirement. Only about 0.2% is used for farm mechanization in developing countries. From these figures we should not draw the conclusion that the energy supply for agricultural production is of secondary importance. On the contrary, development of agriculture depends to a large extent on the availability of energy at a reasonable price. Greater scarcity and/or higher costs of fossil fuel reqires that : (a) high priority be given to fuel supplies for food production, including production in developing countries ; if cuts in consumption must be made they should fall on other sectors of economy, especially prfvate transport, fuel for heating, air conditioning, etc.; (b) best use be made of available fuel supplies by ensuring maximum efficiency by the correct selection and use of powered equipment; (c) long-term efforts be directed to the use of alternative energy sources such as solar and wind energy, use of crop and animal wasts for fuel.

National Mechanization Programmes

Farm mechanization problems exist in nearly every developing country and governments will have to pay more attention to the appropriate introduction of technology in agriculture. Agricultural development requires a clear policy concerning mechanization but very few countries have given due consideration to this important problem in their general development plans. A clear government policy is particularly important as both import of machines and the consequent requirements of fuel and spare parts usually require foreign currency. Promotion of national agricultural engineering programmes should be regarded as an essential part of development. Institutes and advisory boards with the required technical competence could play a very important role to :

—Advise the government on all subjects concerning agricultural engineering and advice concerning mechanization policy.
—Organize and conduct training programmes at various levels for farmers, operators, mechnics, local artisans and extension staff.
—Organize and establish testing and evaluation programmes. Testing and evaluation of existing machinery and their adaptation for local conditions is usually a cheaper and quicker way of development than work on new designs.
—Assist and promote local manufacture of suitable equipment and machinery.
—Conduct and/or stimulate applied research in the relevant problems faced by the country and the farmer.

Regional and Inter-Regional Agrcultural Engineeing Programmes

Regional and inter-regional agricultural engineering programmes cannot substitute national programmes but should support the aims and goals of national activities. Such regional activities could be :

—Research on specific problems common to all the countries.
—Maintaining documentation and reference services.
—Establishing and maintaining institutions providing advances training and education.
—Organizing and contultative meetings on topics of common interest.

Driverless Field Operation Apparatus

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Labor Shortage

Labor shortage in Japan is considered to be serious after 1975. The population of younger generation (age 20-30) who are the nucleus of labor will reach its peak in 1975, and then will decrease rapidly by 3 million in five years (between 1975 and 1980).

Number of youths in the 20s who are engaged in agriculture is assumed to be less than one million at pressent. If three million youths are decreased in near future, how many youths will still be engaged in agriculture?

Moreover, wage is rising every year by 15%. It meams that wage level will be twice in five years.

One of the measures for this labor shortage and wage soar is to larger the size of machines. But the reduction of labor through larger size machines is limited in the rice field in Japan, and revolutional method is necessary for big reduction of labor. That is automation.

Safety Problems

Among the subject presently calling public attention are the problems how to secure "safety" and how to improve "ridability".

In some foreign countries, it is reported that about 20 persons are killed annually at tumbling accidents every 100,000 tractors. As a preventive means, rapid universal use of "safety frame" and "safety cab" are recommended as an urgent step.

As the history of tractor utilization extends longer in Japan, increasing number of operators are complaining disorder of internal organs or trouble of hearing. It is urged to take immediate measures to reduce vibration and noise.

In efforts to counter such troubles and improve the maneuverability of agricultural tractors, engineers concerned are working earnestly to develop engines of fuel cell application and tractors with a stepless speed gears of hydrostatic drive. These powerful yet gentle-working machines are expected to be completed very near in the future for practical utilization.

Necessity of Unmanned Operation

Even with these improved machines, the tractor work is a mere repetition every year of monotonous job on a vast field with practically no people to be seen. He has to withstand a long continuation of constant strain. Although the tractor service is accepted as a common kind of job in the present circumstance, it will be felt as a tedious and tiresome kind of work in the future with the elevation of cultural level of people at large and with the change in their concept of value.

Quite different from the case of automobiles, there is no need for people to ride the vehicle in the agricultural work, properly speaking. It may be anticipated that the way of agriculture will advance further from "riding" to "non-riding" farming by and by so as to enable farmers to be engaged in more efficient jobs in the future.

Method of Unmanned Farming

Research on automatic field work has been conducted since quite early in many countries. Classified broadly, there are "semi-automatic system" and full-automatic system."

Included in what may be

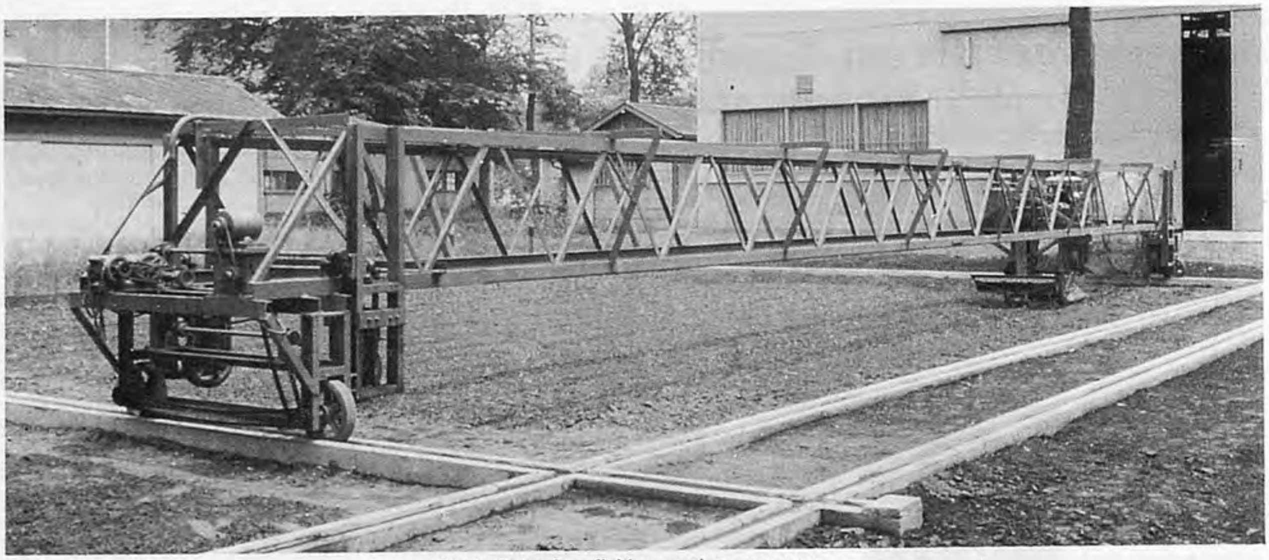

Fig.1. Driverless field operation apparatus

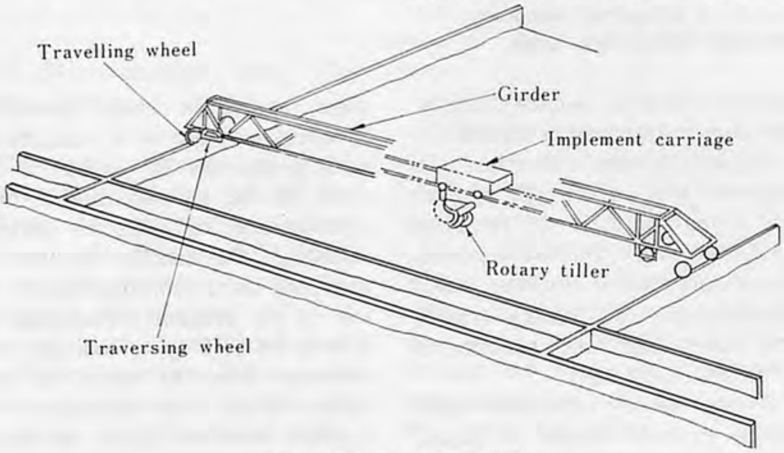

Fig.2. Schema of apparatus

grouped in the semi-automatic are so-called remote-control system in which the tractor is operated from on the ground or in the room or several parallel-running slave tractors by an operator riding a master tractor and direct control system in which the tractor is automated in straight travelling or in working attachment operation; but in other motions it is controlled by the riding operator.

In the full-automatic system, no operator is required; and the tractor is automatically controlled by light, infrared rays, electro-magnetic waves, etc. through the medium of underground cables for induction and computers arranged at appropriate positions.

Driverless Field Operation Apparatus

The Institute of Agricultural Machinery has developed a new type of machine in 1970 which is different from a conventional tractor. It is called "Driverless Field Operation Apparatus" (See **Fig. 1**).

The structure is as illustrated in **Fig.2**. A lengthy-frame (girder) travels on the concrete levees on the two sides of a field and the carriage travels on the girder, doing its assigned field jobs as it rolls on the latter across the field.

As this working carriage reaches the field edge, the power on-off device acts to stop the travel of the carriage and the working tool comes up. Then the carriage retreats to the initial position and at the same time the girder moves by a necessary furrow width. Here you come to an end of one cycle.

The same cycle is repeated till the girder reaches the last end of field furrows. Then the switch works to change the direction of the girder wheels (or lower the laterally-directed wheels provided for that purpose), and the girder moves crossways into the second row of the field. The above described course of work is repeated thereafter (See **Fig.3**).

Merits of The Apparatus

The merits of the driverless field operation apparatus are as follows:

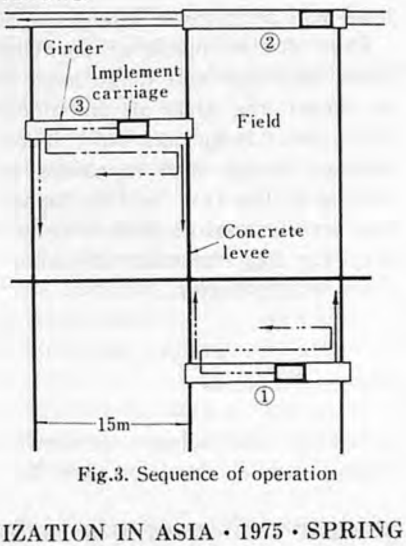

Fig.3. Sequence of operation

Table 1. Working hours of walking and riding tractor and driverless apparatus systems

Kind of operation	Working hours (hr/ha)		
	Walking tractor	Riding tractor	Driverless apparatus
Tilling	{ 19.6 19.6	{ 10.7 10.7	0
Puddling	17.2	6.5	0
Transporting of seedlings	16.8	16.8	16.8
Transplanting	53.0	53.0	0
Weeding	{ 1.6 1.6	{ 1.1 1.1	0
Spraying & dusting	11.6	7.6	0
Reaping	45.5	} 45.6	
Transporting of bundles	29.2		0
Threshing	84.8		
Transporting of paddies	15.0	15.0	15.0
Total	315.5	168.1	31.8

(1) Needless to say, required labor can be reduced remarkably. Though sub-labor is necessary in the case of transplanting and harvesting for transporting seedlings or paddies, no labor is required at all for tilling, puddling and dusting (**Table 1**).

(2) As there is no operator it is not necessary to take a rest. It can work continuously day and night. Furthermore, there is no safety hazard such as overturning, vibration, sound, and chemical poisoning.

(3) Simultaneous operation of machine, same kind of works or different works such as puddling and transplanting, can be done in the case of automatic operation.

(4) As this apparatus travels on the concrete levee, there is no problem of trafficability even on very soft wet soil or ridged field. Even the mechanical intercultivation in the flooded field is not difficult. There is no soil disturbance and compaction which will lead to poor permeability. Furthermore, the implements run completely straight, through which crop damage will be least.

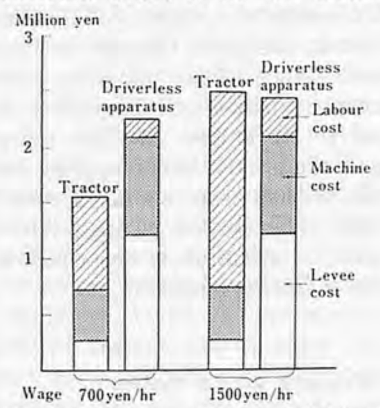

Fig.5. Annual cost of tractor and driverless apparatus systems (Acreage : 7ha)

Economy of The Apparatus

Although it is an ideal goal to materialize a manless field work, if it involes too large a sum of expenses, it must be said to be of no use. So let us roughly compare the expenses required by the driverless apparatus with those involved in the manned tractor.

As regards operation capability, suppose the manned tractor work 8 hours per day, neglecting the preparative and adjusting time for the machine, while the driverless apparatus may be operated all day and night, that is, it can work 24 hours, three times as long as the tractor.

Suppose the output of the driverless apparatus is 6HP, then in order that the manned tractor carry out the same tilling work done by the driverless apparatus in one third the time of the driverless unit's operation, the tractor must be a unit of 20HP class.

So let us compare the expenses required by this driverless apparatus with those needed by the 20HP class tractor unit.

In the case of the manned tractor, if simple block levees are used for the saving of levee

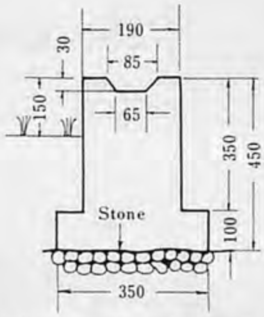

Fig.4. Cross section of concrete levee (Unit : mm)

plastering labor, some 800 yen/m will have to be paid off. On the other hand, the driverless apparatus needs concrete levees (See **Fig.4**), which costs about 3,500 yen/m.

With regard to the expenses for machine, the price of driverless apparatus is assumed to be five million yen and that of manned-tractor system (20HP tractor, 2 row transplanter and 2 row combine) to be 2.6 million yen.

If we assume the service life of levee to be 20 years and that of machine to be 10 years, the total annual cost will be as shown in **Fig.5.** The levee cost of driverless apparatus is about three times as those of tractor, but labor cost is only one fifth of tractor. Therefore, at the present wage level of 700 yen/hour, the operating cost of apparatus per year is about 700 thousand yen higher than that of tractor system, but at 1,500 yen/hour both will be almost the same.

However, such a comparison of cost for rice cultivation alone is not so significant. The important value of driverless apparatus is in the fact that the farmer can be engaged in the all-year-round job in addition to the rice cultivation by the introduction of the apparatus. In other words, if the farmer can get income of 700 thousand yen per year from outside of rice cultivation, the driverless apparatus can be paid enough even at the present wage level.

The Recent Condition of Agricultural Mechanization in Japan

Computerized Control System for a Large-scale Horticulture Facility

by
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Intoroduction

The horticulture using facilities in Japan has kept expanding, supported by a growing tendency for a larger scale facility year after year, so that that area covered by this cultivation method now amounts to 1,000 hectares by glass greenhouses, and 19,000 hectares by vinyl greenhouses that are used for the cultivation of vegetables, flowers and fruit trees. Of these, 50% of the 1,000 hectares by glass greenhouses is used for the production of flowers which may be called man's mental food.

The environmental control techniques, which have been developed along with the mechanization of holticulture facilities of increasingly larger sizes are based on separate control of environmental conditions and on availability of a large amount of energy to run the entire system. The primary aim of agricultural production techniques is in effective exploitation of natural resources such as the sun, air and water in cultivating animals and plants for commercial purposes, and horticulture using facilities by no means rejects such natural resources. Rather, it must be carried on with due regard for natural phenomena, because a mere mechanical conditioning is far from sufficient, and there is an urgent necessity to study and develop a complex control system in which the laws of nature are fully applied in developing botanical functions of plants.

As an experiment in this line, the authors completed a system intended for a future practical use, in the experimental farm affliated with the Department of Agriculture of the Shimane University in July, 1974. The system has gone through various tests since then, and the first crop of irises was harvested in early November of the same year. It is now being applied for the second crop, so far successfully. The outline of the system and its operation is described in the following pages.

Structure of the system

The system has been tested on

※Matsue-shi, Shimane-ken, Japan

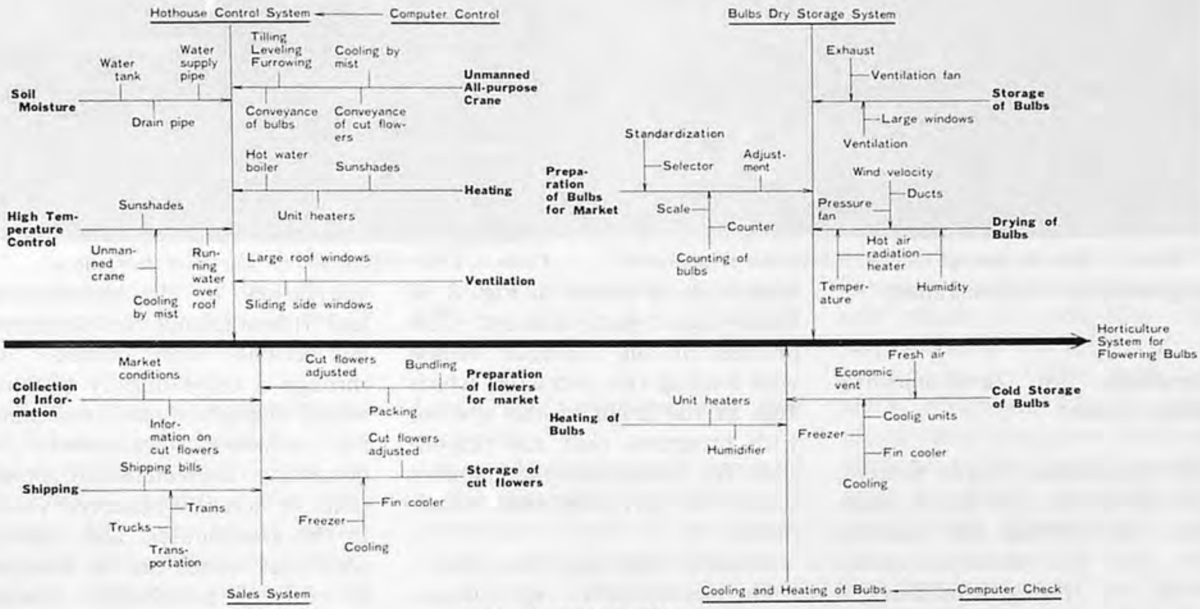

Fig.1 Description of the system

flowering bulbs for the reason that cultivation on bulbs and cultivation of cut flowers from such bulbs have so far been carried out as completely separate systems, with no efforts for integration of the two processes into a continuous production system, and that although flowering bulbs have very delicate botanical properties, they require very little tending by man, which means less danger of disturbance by man of the environmental conditions in the greenhouse during the system run, and therefore, a higher reliability of the output data. Another reason is that we had a sufficient compilation of program specifications required for the actual computer control.

As is shown in **(Fig. 1)**, a computerized control system for cultivation of flowering bulbs was completed, and facilities were built for its full application.

The system, aiming at an integrated production of tulips, irises, or gladioluses from bulds to cut flowers, includes four subsystems, i.e., a bulb dry storage system, a system for heating and colling of bulbs, a greenhouse control system, and a sales system, each of which is provided with its own control capacity, as well as being an integrated unit of the total system. The major portion of the computer capacity is appropriated to the control system of the greenhouses which are exposed to incessant changes of various natural phenomena.

Cultivation pattern of flowering bulbs

Two greenhouses, 800m^2 each, are to be used in the experiment, in each of which 100,000 pieces of bulbs each time are to be planted. (Only one of the greenhouses has been completed.)

Various techniques of forcing and late raising are widely used so that some flowering bulbs or other are always being cultivated in the greenhouses throughout the year, according to the temperature processing calender **(Fig. 2)** for cooling, heating and greenhouse raising of bulbs. Every bit of the bulb dry storage room, the heating and cooling room and the greenhouse contributes to the best development of physiological properties of flowering bulbs, since the primary requirement of controlled cultivation is to maintain respective bulbs in the best environment at each step of the cultivation process. The bulb dry storage room **(Photo 1)** and heating and cooling control

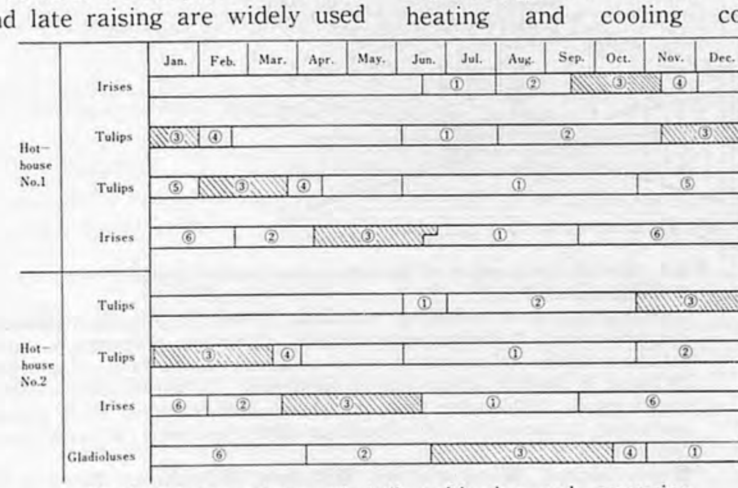

Fig.2 Planting scheme of bulb cultivation and processing schedule by each room.
①Drying room ②Cold storage room ③greenhouse
④Flowers stored ⑤Refrigerator ⑥Heating room

Photo 1. Bulb dry storage room with ducts and drying racks

Photo 2. Color display used for corrective instructions

equipments are thus installed.

Framework of environmental control system

The centralized control system, supervising the bulb dry storage room, the heating and cooling room and environmental conditioning in the greenhouses is based on a prerequisite that almost all the works are mechanized, so that to make the best advantage of the computerized system, it is very important that man should clearly tell the machine what to do. The overall system, as is shown in **Fig. 3**, is based upon such concept. The process of the dialogue begins with loading the computer, which acts as the brain of the system, with programs that are responsible for judgments on complex control of environmental conditions.

Required data have been drawn from established agricultural theories as well as empirically, and constructed as a number of programs on tape, which are then fed into the computer via a typewriter coupled with the computer.

Confirmation of actual state of cultivation in the greenhouses and transmittance of corrective instructions are arried out through a color display terminal which displays memorized planting schemes, parameters to determine environmental conditions or actually observed values in the greenhouses, and through which set values can be changed in case of a schedule change. (**Photo 2**)

The environmental control panel is equipped with an operation monitor and an alarm to quickly discover any abnormality in the operation of the greenhouses. There are also a graphic

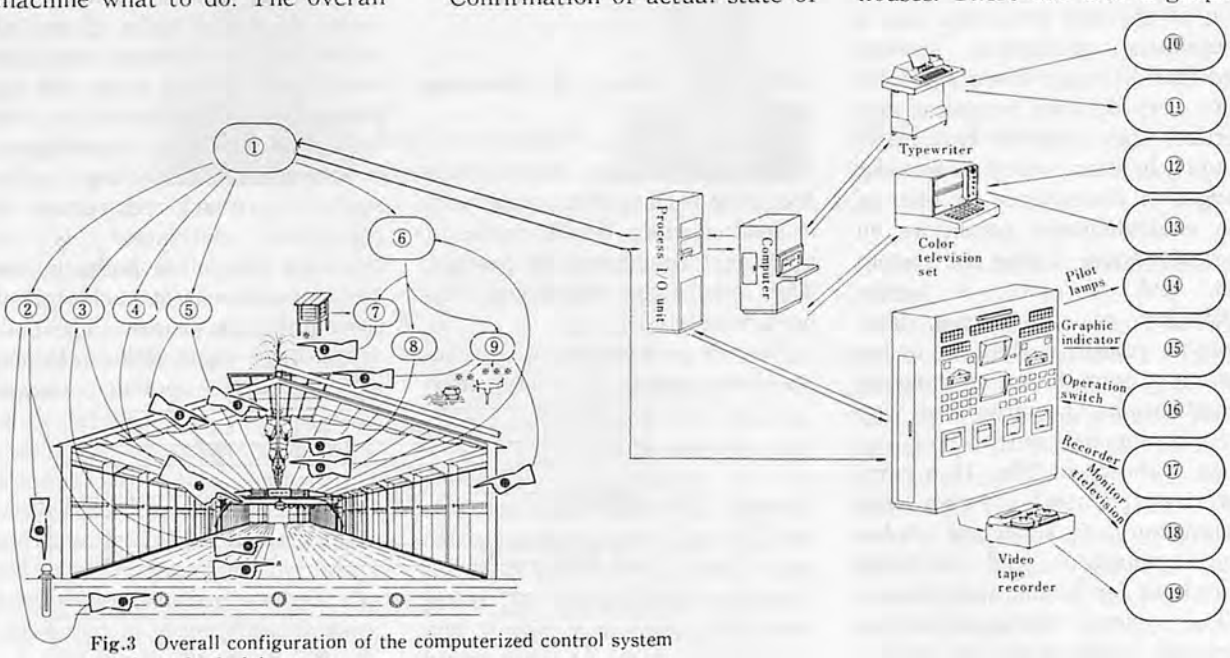

Fig.3 Overall configuration of the computerized control system
①Annual schedule
②Underground water sprinkling ③Cooling by mist ④Spraying of chemicals & fertilizer ⑤Sunshade ⑥Temperature control ⑦Rooftop water spraying ⑧Heating ⑨Opening & closing of windows
⑩Basic schedule ⑫Preparation of daily report; ovserved values of environtal constituents; state of operation ⑫Change in planting scheme and/or parameters ⑬Planting scheme; control parameters; alarm parameter; obserred values ⑭Operation pilot; breakdown pilot; observed value abnormality ⑮Operation pilot ⑯Manual operation ⑰Observed values of environmental constituents ⑱Status quo in the hothouses ⑲Status quo in the hothouse
❶Water sprayed ❷Roof windows ❸Sunshine ❹Sunshades ❺Heating units ❻Room temperature ❼Cooling by mist spray; spraying of chemicals & fertilizers ❽Underground temperature ❾Underground water level ❿Underground humidity ⓫Underground sprinkling ⓬Side windows
※Outside atmospheric temperature ※※Precipitation
※※※Wind direction; wind velocity

Photo 3. Central control panel (right)

Photo 4. Central control room with appropriately laid-out equipments

panel having the shapes of the greenhouses, with pilot lamps to tell what are being done by the machine (**Photo 3**).

All the data on environmental conditions are recorded as either analog values or digital data, via the control panel and the typewriter. Any mechanical breakdown or abnormality in environmental conditions activates the alarm, and the contents of such abonormalities are typed out, telling the time of recurrence and recovery to normal conditions. All of these equipments are installed in the central control room (**Photo 4**) for the purpose of a completely centralized control. Specifications of the system control equipments are given in **Table 1**.

Environmental control in the greenhouses and the greenhouses facilities

Structure of the greenhouse

Upon planting of bulbs begins the environmental control in the greenhouses. Since the purpose of our environmental control is, as is said before, to effectively exploit the sun, air and water without disturbing the total circulation of natural phenomena, we need to have greenhouses whch are not only built economically, but also are able to function most efficiently to materialize the above purpose. The ones we have built are made of commercially available frameworks of 2.5m in width and 87.5m in length, the latter consisting of 35 spans of panels each 2.5m wide, on the ground space of approximately 800m² each. To these skeltons, we introduced many functional devices which are descrived below.

Large roof windows and side windows

A good ventilation is essential to the year-round operation of a greenhouse. Each of our greenhouses is equipped with two large roof windows, each 80cm wide, corresponding to 18% of the ground space. The both side walls, which are 2.3m in height, are divided into two horizontal sections to be made into side windows which can be slided open by 50% (**Photo 5**).

Table 1. System control equipment specification

1. Control computer system (YODIC-100 System)		
C P U (1 Unit)	Memory	16 K-words (core memory)
	Word-length	16 bit
	Cycle time	10 m.s. (actual)
System typewriter (1 Unit)	Function	Printing Paper tape punch paper tape read
	Printing speed	1,000 character/min
Tape reader (Photoelectric) (1 Unit)	Reading speed	Approximately 400 codes/sec
Process I/O unit (1 Unit)	Analog input (0 - 10mVDC)	32 points
	Digital input	96 points
	Digital output	64 points
Color display unit (1 Unit)	Screen size	14 inches
	Character sets	Numerics. alphabets, space, kana, special characters
	Number of characters displayed	16 32-character lines (512 characters)
	Colors displaved	Red, green, blue, yellow, cyan, magenta
	Equipped with keyboard-type operator input-output unit	

2. Equipment on instrumental panel (Common to No. 1 and No. 2 greenhouses)			
Analog recorder	Input points	Temperature: -10 - +50°C	24points
		Soil moisture: 0-20% Sunshine: 0-300 $\times 10^3$ Lux Precipitation: 0-25mm	25points
		Wind direction: NESW Wind velocity: 0-60m/sec	2pens
Switches 29	Automatic/manual switch-over, and manual operation		

Push button switches	Timer (for crane operation)	Pilot lamps	Graphic
8	1	56	2

3. Monitor Telvision 1 unit for each greenhouse		
Monitor television (17 inches, monochromatic)	Television camera (remote controlled)	Video tape recorder
1	1	1

4. Detector/Convertor			
Room temperature	Temperature detector 16	Soil temperature	Temperature detector 6
	Convertor (6 points) 2		Convertor (6 points) 1

Soil moisture detector (dielectric constant type)	Sunshine detector (photoelectric type)	Heavy-rain gage (drip counting type)	Rain gage (measure turnover type)	Wind gage (propeller type)
6	4	1	1	1
Common convertor		4		

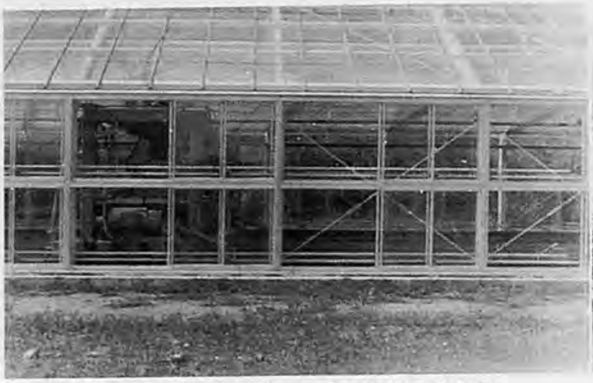

Photo 5. Horizontally sectioned side windows

Photo 6. Rooftop water sprayers in operation

As a warrant against possible vulnerability to the wind and rain, resulting from large openings, wind and rain control systems have been established by loading the computer with protective measures. The opening and closing of the windows are done by an instruction from the computer, based upon comprehensive judgment on set temperature values and actual direction of the wind, in the same way as by overall judgment by man.

The temperature parameters used here vary according to specific steps of the growth of plants and daily time zones, and they determine an appropriate schedule so that the best temperature is always maintained by means of opening and closing of roof windows and side windows.

Cooling of the roof by running water

Another effective temperature control means is the cooling of the roof by evaporation of water which is sprayed upon the roof through nozzles. The sprayed water mist will absorb the solar heat while running over the roof, and will cool the atomosphere surrounding the greenhouses when the same water runs down in screens from the roof, and the cooled air will further control the greenhouse atmospheric temperature down (**Photo 6**). This process is automatically activated upon an instruction from the computer. During the winter when it snows, the water sprayer also serves for melting of the snow laid upon the roof. Again, this is done by the computer which responds to the atomospheric temperature outside the greenhouses.

Sunshades

During the growing period of bulbs right after their planting, too much sunshine only does harm to the growth of the roots. When the greenhouses are judged to have got too sunny, according to the specific parameter for each growth stage, the computer will transmit instruction to furnish roof screens, and in the evenings when it has resumed appropriate sunshine, the screens will be automatically removed. These screens may be used both for controling the growth of plant roots and the room temperature.

Heating

Heating is by hot water circulation system, or more specifically, by overhead radiation heating system in which hot air heated by hot water is blown off from the heating units which are hung on the ceiling for the best efficiency of the cultivation beds and for the best overall economical advantage. When the measured values reach the lowest limits of the set values for a specific season, growth stage, and daily time zone, the computer will transmit an instruction to automatically activate the three-way valves and the heating units in order to maintain a desirable room temperature.

Unmanned all-purpose crane

In view of possible undesirable effects on the health of workers, which could result from working inside the greenhouses that are maintained in a drastically different environment from outside, and for the purpose of work simplification, there has been a strong necessity for complete mechanization of cultivation control and conveyance of crops in a greenhouse. While only partial attempts toward such purposes have previously been made, the authors have developed an unmanned all-purpose crane which is capable of environmental control as well as being a machine crane.

Outline of the structure of the crane and its functions

Our crane has an appearance of a gantry crane (**Photo 7**), consisting of the track, the gantry crane and the control units. To ensure the maximum operation space of the crane (i. e., the maximum cultivation space), the greenhouse, 9.1m in width and 2.3m in eaves height, are provided with sliding windows, along the inside of which rails are furnished. The sliding windows have been chosen because they do not need arms to open and close the windows. The performance of the crane is outlined in **Table 2**.

The track—The H-shaped track is firmly built sharing a common foundation with the greenhouse framewark.

The crane—The crane frame is made of steel pipes and is constructed in a drum shape so as to adjust meandering and bending during the operation (**Photo 7 & 9**). The gate pillars will also act as a vertical travelling guide for the girder. The saddles are provided with reinforced urethane wheels so as to absorb shock and noises during the run. The crane is driven by two 3-phase induc-

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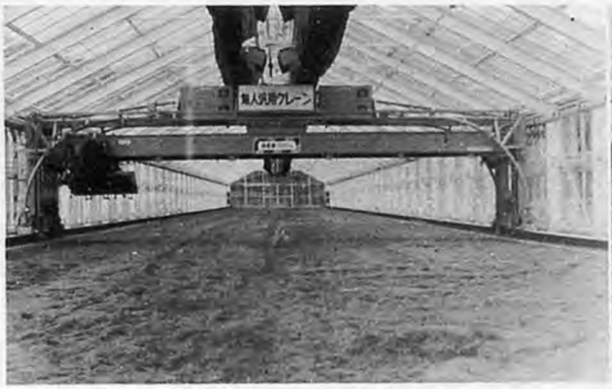


Photo 7. Overall view of the unmanned all-purpose crane

Photo 8. Rotary tiller simultaneously conducting tilling, leveling and furrowing

tion motors with variable speeds of 140rpm to 1.400rpm to handle works of various natures. The both motors self-control meandering, detecting loss of speed resulting from resistance during the operation. The main frame of the girder is assembled from shaped steel, and it also acts as a conveyer. The track for a traveling crab is attached on the bottom of the girder as a rack. The crane travels vertically by chain block motors on both sides. The horizontal load is indicated by a guide rail in the gate pillars. A rotary enables tilling in both directions by the use of a power cylinder. The tilling craw has a shape of a specially designed hoe in order to ensure the best efficiency in the two-way tilling. The ground leveler and furrowing craw are integrated into one unit so as to simultaneously conduct tilling, leveling and furrowing of the ground. Electric power is supplied from the trolley wires on the upper end of a side of the crane.

The control units—The crane control is by a multiple communication device in which the crane control panel in the computer room is corelated with the controlpanel on the crane for the purpose of a two-way communication. A bus duct on the upper end of the other side of the crane than that used for power source contains communication wires. Selection of the job is by a switch using no-contact relays. The crane also can be manually operacted by switching over.

Functions of unmanned all-purpose crane

Automatic tilling—Automatic tilling is done according to a pre-determined work schedule. The operation speed during actual tilling is 20m/min, and the revolving speed of the rotary tilling shaft is 198rpm. Consequently, six steps of back and forth horizontal travelling of the crane in a greenhouse 9.1m wide and 87.5m long requires 32 minutes for tilling, leveling and furrowing (**Photo** 8). By setting a time to begin tilling on a self-timer on the central control panel in the computer room, along with necessary instructions, the job is done automatically, regardless of night or day, and the ground is all ready for planting. The rotary is constructed for an easy mounting and dismounting so that after tilling, it can be replaced by a motorized water sprayer. A switch facilitates manual operation as well, and the operation speed can also be reduced to 10m/min.

Cooling by mist—During the greenhouse cultivation of cut flowers from bulbs, it sometimes happens that the atmospheric temperature and ground temperature are too high for the adequate growth of the plants. The temperature control in greenhouses are usually done by ensuring a good ventilation by large winddows and by sprinkling water over the roof in order to reduce the temperature of the incoming air. Another theoretically accepted method is to spray fine mist within the greenhouse to make use of evaporation heat for cooling. Therefore, our crane is furnished with a device to detect the underground temperature of 1cm deep beneath the ground surface, and upon an instruction from the computer, to automatically spray water in fine mist while traveling over the cultivation bed (**Pwoto 9**). During 20 minutes of going back and forth

Table 2. Performance of unmanned all-purpose crane

Unmanned all-purpose crane for greenhouse					
Span		7.950mm	Cultivation bed width		7.600mm
Height of saddles		2.125mm (from G.L.)	Height of frame		2.630mm (from G.L.)
Traveling	Speed	Revolution	Motor output 2.2KW (2)	Reduction/transmission unit (1/40)	
	33m/min	1,400rpm		1st step	(worm) 1/20 reduction
	22m/min	940rpm		2nd step	(chain) 1/2 reduction
	11m/min	470rpm		Travel distance	87.5m
Diagonal travel (Reduction motor for hoist saddle)	Speed	9m/min	Vertical travel (Electric motorized chain block)	Speed	3.9m/min
	Motor output	0.26KW		Motor output	1.4KW
	Travel distance	(crab center) 6.6m		Travel distance	1.29m
Minimum height of girder upper face(from G.L.)		650mm	Power source		220V 3-phase
Maximum height of girder upper face(from G.L.)		1,810mm	Source supply method		Trolley wires
Hitch height at maximum girder height (from G.L.)		1,173mm	Operation signal		Bus duct

Photo 9. Crane spraying mist for cooling

Photo 10. Crane carrying bulds for planting

at the speed of 10m/min, 300 litters of water can be sprayed. When the underground/temperature is still higher than the parameter value in 10 minutes after the crane has finished spraying and returned to its set position, the computer will instruct the crane to repeat the same operation. The continuous operation is carried on in a cycle of 30 minutes until the underground temperature is reduced to the parameter value. It has been obsbrved that the atmospheric temperature of 10-20cm above the ground surface goes down rapidly by 2.5-3.0°C by spraying water when the atmospheric temperature starts to rise, and that one round operation of the spraying helped to hold the temperature down for 30 minutes after the spraying. The underground temperature does not go down so quickly as the atmospheric temperature, but repeated operation of the sprayer was effective in controlling the rise of the underground temperature. The temperature of the leaves of plants responded in a similar way as the atmospheric temperature, and the temperature of bulbs plotted a curb similar to that of the underground temperature.

Conveyance of bulds and cut flowers—The crane can be manually operated in order to simplify the conveyance of 100,000 pieces of bulbs to be planted, weighing about 2,600kg in all, and also for a higher efficiency in flower cutting. The conveyer is run at the speed of 33m/min, carrying 500kg of bulbs each time to the end of the greenhouse (**Photo 9**), or carrying out a large quantity of picked-up flowers in only a few minutes (**Photo 10**), resulting in a remarkable work simplification.

Sprinkling of agricultural chemicals and liquid fertilizer, the computer will instruct the date of sprinkling according to a given cultivation program, and upon observation of the plants, the cultivater determines actual sprinkling. When a predetermined amount of chemicals or liquid fertilizer has been dissolved in the water tank in the boiler room, the control panel in the same bolier room catches and transmits operation command for automatic spraying via the push button in the computer room.

Future problems and prospects

It is assumed that this is the first case of a system development on environmental control in a greenhouse by computer, intended for a practical application, and that there are many points left for a future study. With practical applicability in mind, the authors have rendered their experiment on programs on a 16-K words computer, to cover a planting scheme in which two series of cultivation, four crops each will produce cut flowers for 200 dayss a year. Since the greenhouses used in the experiment, 800m^2 each, are of a practically applicable size, the same planting scheme can be expanded into a centralized control system covering 30 to 40 hothouses of the same size (i.e., the total area being 24,000m^2—32,000m^2).

The 16-K words computer used here can be applied to a system including 30 to 40 greenhouses where vegetables and flowers of twocrops-a-year type are planted in, for example, five different schemes to ensure a long term continuous shipping of the crops. By introducing a computer, man can leave environmental control in the greenhouses to the machine, and concentrate himself on observation and management of cultivated plants, thus producing high quality products. This will lead to reduced scattering in the quality of products in a given region, and can contribute to improving the image of the region as a whole.

In a computerized environmental control system, the computer may be compared to the brain of a man, the automatic control units, to the limbs. Even if the computer has been loaded with proper programs, no satisfactory results can be expected without appropriate control units and a controling center to put the programs into practice. What is ugently needed is, therefore, more and more of further studies and development in this field, especially, the development of techniques to convert into electrical signals various growth states of a living plant without destroying its biology.

Another requisite for a future expansion of computerization is the study on growth models of various plants. It seems necessary that more efforts be directed to the study and establishment of growth models of many other plants than those experimented by the authors, and this, in our view, is the most important subject of an immediate study.

The Recent Condition of Agricultural Mechanization in Japan

Transplanter and Harvesting Machines for Rice-plant

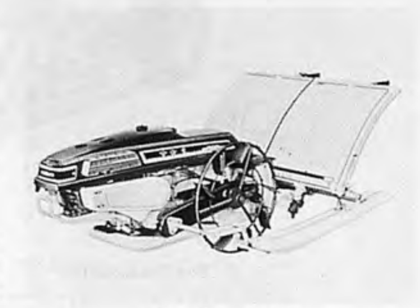
by Farm Machinery Industrial Research Corp.

Japanese agriculture has developed from mechanization centering on rice cropping. Under these conditions, rice planting and harvesting work were most backward in mechanization, even though which must have been required severe labour.

In recent years, however, mechanization in rice planting and harvesting made a rapid progress, due to development of excellent rice-transplanter and harvesting machine.

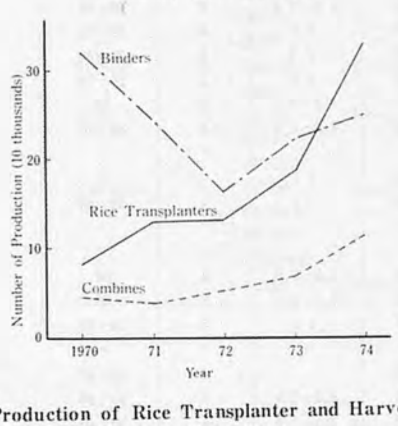
Up as of 1974, we assume that 750,000 rice-transplanters 1,400,000 binders, 330,000 head feed combines are extended broadly in a farm.

Recent condition of rice-transplanter, combine and binder is summarized below, by statistical charts and other datas:



Rice Transplanter

Production of Rice Transplanter and Harvesting Machines in Japan

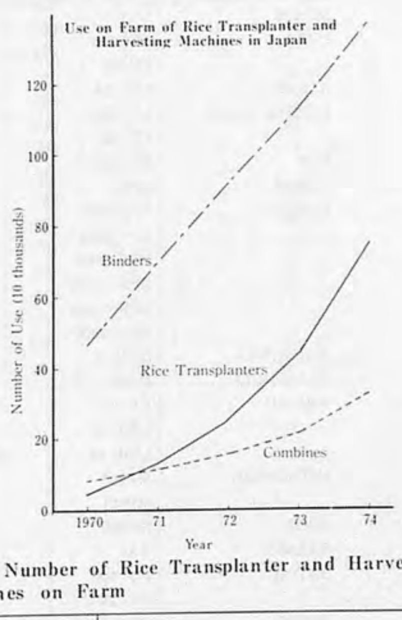


Yealy Production of Rice Transplanter and Harvesting Machines (Q: Quantity···Number, V: Value···¥1,000)

		1970	1971	1772	1973	1974
Rice Transplanters	Q	80,601	129,796	132,158	186,142	330,000
	V	8,768	14,679	15,600	25,686	
Binders	Q	322,421	245,369	164,893	222,607	250,000
	V	43,731	27,404	15,389	24,195	
Combines	Q	44,934	38,159	50,424	68,279	116,000
	V	19,905	15,166	24,141	36,387	

Source: Year Book of Machinery Statistic by M.I.T.I. of the Japan (Figures of 1974 according to estimation by Japan Agricultural Machinery Manufacturers' Association)

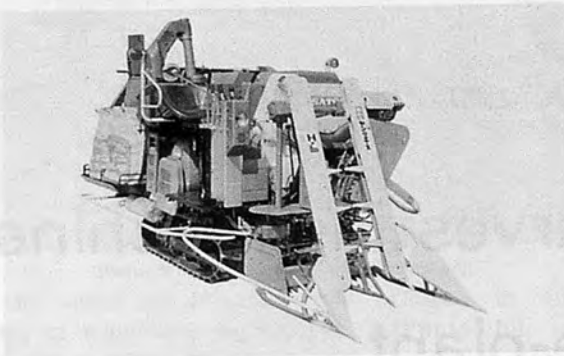
Use on Farm of Rice Transplanter and Harvesting Machines in Japan

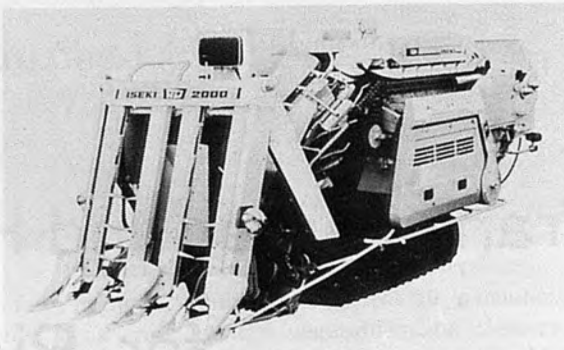


Yearly Number of Rice Transplanter and Harvesting Machines on Farm

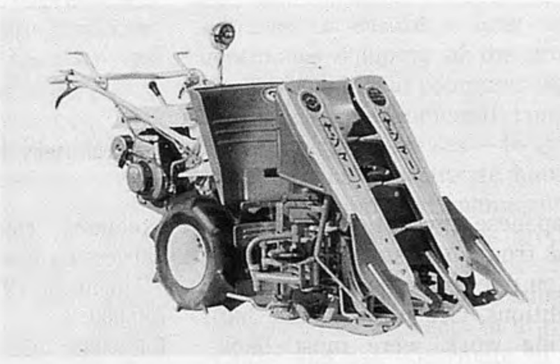
Year					
Rice Transplanters	46,160	128,320	248,260	434,550	750,000
Binders	464,900	704,490	920,260	1,129,200	1,370,000
Combines	84,190	116,990	158,720	217,070	327,000

Source: Statistical Yearbook of M.A.F. of the Japan (Figures of 1974 according to estimation by Farm Machinery Industrial Research Corp.)





Head Feed Combine



Binder

Specification of Selected Machines

(1) Rice Transplanter

Brand	Model	Dimensions (cm) Length×Width×Height	Weight (kg)	Engine Out put (ps)	Nember of Row	Efficiency (min/10a)
HONDA	ACT	201×86×94.5	72	2.0~2.8	2	50~70
ISEKI	PF200	200×90×85	65	2.5~3.5	2	60
〃	PF400	240×148×82	155	〃	4	30
KANRIU	8T2-2A	170×85×80	70	2.2~3.0	2	60~90
KIORITZ ECHO	LT-2F		72	1.0	2	50~60
〃	LT-4F		157	2.3	4	30~40
K-O	RT-20C	201×86×94.5	72	2.5	2	50~70
KONMA	KP3	200×90×85	67	2.5~3.5	2	60
KUBOTA	SP-S280	197×86×86	65	1.6~2.4	2	40~70
〃	SP-S300	197×88×86	〃	〃	〃	〃
〃	SPS-3300	175×91×82.5	62	1.7	〃	〃
〃	SPS-120A	216×141×100	120	3.5	4	25~40
〃	SPS-120B	216×145×100	〃	〃	〃	〃
〃	SPS-4000	216×155×100	〃	〃	〃	〃
MAMETORA	MSP-2	200×90×85	78	2.5~3.5	2	60
MARUMASU	MSP-2	200×90×85	78	2.5~3.5	2	60
MINORU	LT-2F	203×72×92	76	1.4	2	50~90
〃	LTH-2F	〃	〃	〃	〃	〃
〃	LTH-4F	248.5×204.2×99.5	158		4	30~40
MITSUBISHI	MP205	190×90×120	73	2.0~2.5	2	45~80
〃	MP401	210×150×120	120	2.5~3.5	4	30~40
NODA	NP30B	190×86×80	75	2.2~3.4	2	60~90
SATAKE	TA4	180×100×100	100	5	4	60
SATOH	PS-400	210×150×120	120	2.5~3.5	4	30~40
〃	PS-220	190×90×120	73	2.0	2	45
SUZUE	SP2B1	201×86×94.5	72	2.5	2	50~70
〃	PP2B	201×95×94.5	75	〃	〃	30〃
〃	SP4	205×146×100	115	3.5	4	30~50
〃	PP4	205×185×100	120	〃	〃	〃
YANMAR	FP2B	204×80×80	62	1.7	2	60~90
〃	YP2	200×86×89	70	1.6~2.4	〃	〃
〃	PP4	200×145×95	120	2.3~3.4	4	30

(2) Head Feed Combine

Brand	Model	Walking or Riding	Dimensions (cm) Length×Width×Height	Weight (kg)	Engine Out put (ps)	Cuting Width (cm)	Efficiency (a/hr)
FUJII	FK1200	Riding	378×221×195	1550	23	120	45~60
〃	FK700	〃	268.5×220×133	630	10	60	60~90
〃	FK50	Walking	257×205×129.5	500	8	〃	120~180
ISEKI	HD2000D	Riding	383×169×190	2030	25	140	15~30
〃	HD1500	〃	329×168×162	1160	18.5	105	30~48
〃	HD1000	〃	275×155×150	680	13	75	60~84
〃	HD800	〃	268×155×153	580	10	75	84~108
KIORITZ ECHO	KM-70C	Walking	227×150×127	400	6.5~8	70	42~75
〃	KH-70F	Riding	270×165×177	670	8~11	〃	75~120
K-O	CM-500	Walking	202×120×122	300	5.5~7.5	45	90~100
〃	CM-70G	〃	227×150×127	400	6.5~8	65	65~70
KONMA	CB75E	Riding	273×161×145	690	11~15	70	60~80
KUBOTA	HX550-A	Riding	248×158×147	630	8~11	75	55~85
〃	HX550-D	〃	〃	〃	〃	〃	〃
〃	HX-D5	〃	〃	780	10.5	〃	〃
〃	HX700-A	〃	〃	650	10~13	〃	〃
〃	HX700-D	〃	〃	680	〃	〃	〃
〃	HT900-B	〃	370×165×180	900	13	90	40~75
〃	HT900B-T	〃	〃	〃	〃	〃	〃
〃	HT1200-A	〃	378×164.5×181.5	1120	16	120	30~46
〃	HT1200-T	〃	〃	〃	〃	〃	〃
〃	HT2200	〃	400×165×195	1750	22	130	
MITSUBISHI	MC1200D	Riding	378×221×195	1650	20	125	45~60
〃	MC850	〃	299.5×180×176	705	15	81	50~80
〃	MC850KE	〃	〃	〃	13	〃	〃
〃	MC850K	Riding	299.5×180×176	700	13	81	50~80
〃	MC800	〃	〃	695	11	〃	〃
NODA	HZ	Riding	297×150×149	750	9~12	70	50~90
OSHIMA	RS-600	Riding	296×183×136	580	7~9	65	80~120
〃	RS-600A	〃	〃	585	8~11	〃	〃
〃	RS-701	〃	302×184×146.5	700	〃	70	60~90
〃	RS-771A	〃	〃	〃	10~13	〃	〃
〃	RS-772D	〃	〃	785	11	〃	〃
〃	RC-901	〃	314×164×151	800	11~15	90	40~70
〃	RC-902D	〃	340×164×151	960	15	〃	40~60
ROBIN	GH52	Riding	240×148×142	660	8~10	50	60
SATOH	H1200D	Riding	378×221×195	1650	23	125	45~60
〃	H850	〃	299.5×180×166.8	705	15	81	〃
〃	H850KE	〃	〃	〃	13	〃	50~70
〃	H850K	〃	〃	700	〃	〃	〃
〃	H800	〃	〃	690	11	〃	60~80
SUZUE	KM70B	Walking	227×150×127	400	6.5~8	70	75~120
〃	KM50	〃	250×185×122	350	5~7	40	90
〃	NC600	Riding	296×136×183	580	8~11	65	80~120
〃	NC772	〃	302×184×166	750	〃	70	60~90
〃	CP730D	〃	257×121×152	700	11~15	73	60~100
YANMAR	TC700	Riding	261×179×147.5	695	8	75	60~80
〃	TC750A	〃	280×195×155	810	10.5	〃	46~66
〃	TC750D	〃	〃	850	〃	〃	〃
〃	TC2000D	〃	381.5×243×165	1470	20	130	30~40
〃	TC400	Walking	226×172×135.5	350	5~6.5	50	150~200

(3) Binder

Brand	Model	Dimensions (cm) Length×Width×Height	Weight (kg)	Engine Out put (ps)	Number of Cuting Rows	Cuting Width (cm)	Efficiency (min/10a)
HINOMOTO	UB-302	160×75×94	82	2.5~3.5	1	30	60~120
〃	RB-300	165×75×130	85	〃	〃	28	170~240
HONDA	T55	188×77.1×117.5	182	3.3~4.5	2	50	60
〃	ACT30	185×66×97	110	2.0~2.8	1	32	70~110
〃	ACTM30	170×66×97	85	〃	〃	30	〃
ISEKI	RS300S	185×64×103	100	2.5	1	25	30~60
〃	RS501	207×85×105	150	5.0	2	50	〃
K-O	BM-300	170×66×97	90	2.3~3.3	1	30	70~110
〃	BS-300	〃	100	〃	1	〃	60~100
〃	BS-600	198×68×90	150	3.0~4.5	2	50	40~80
KONMA	KB305			2.2	1	28	60~90
KUBOTA	HE305A	188×60×87	115	2.2	1	28	60~90
〃	HE305H	189×62.5×90	〃	〃	〃	〃	〃
〃	HE305WH	189×65×90	120	〃	〃	〃	〃
〃	HE205	155×56×80	90	1.8	〃	〃	90~150
〃	HE505A	190×81×88	145	3.1	2	51	40~70
〃	HE6500	190×91×93.5	165	〃	〃	58	35~70
MITSUBISHI	KB200	178×60×95	75	2.0~2.5	1	25	80~130
〃	KB253	178×66×95	90	3.5	1	〃	60~90
NODA	RM30C	170×66×97	90	2.3	1	30	70~110
〃	RT305	189×65×90	120	2.2	〃	28	60~90
〃	RT505	190×81×88	140	3.0	2	51	40~70
〃	RS60C	198×68×90	150	〃	〃	57	40~80
〃	RS30C	170×66×97	100	2.3	1	30	60~100
OSHIMA	FU-301	184×85×93	90	2.2~3.4	1	30	70~110
SATOH	BX-200	175×65×90	75	2.5	1	30	80~130
〃	BX-310	178×66×95	90	3.5	1	〃	60~90
〃	BX-510	195×70×96	130	4.5	2	50	40~70
SUZUE	B301C	170×66×97	90	2.5~3.5	1	30	70~110
〃	B300C	〃	100	〃	1	〃	60~100
〃	B260C	198×68×90	150	3.0~4.5	2	50	40~80
YANMAR	YB101	160×62×95	75	2.3~3.2	1	30	60~120
〃	YB301	159×58×110	85	〃	〃	〃	100~150
〃	YB300A	175×60×100	95	〃	〃	32	60~120
〃	YB600D	210×75×105	150	3.5~5.0	2	58	50~75
〃	YB550A	195×75×100	130	2.5~3.5	〃	55	〃

Manufacturer's Name and Address

Fujii Noki Mfg. Co., Ltd.
285, Koike, Tsubame-shi, Niigata Pref. (Combine)

Fiji Robin Co., Ltd.
8-1, Nishishinjuku 1-chome, Shinjuku-ku, Tokyo. (Combine)

Honda Motor Co., Ltd.
5, Yaesu 5-chome, Chuo-ku, Tokyo. (Rice Transplanter, Binder)

Iseki Agricultural Machinery Maf. Co., Ltd.
2, 2-chome, Nihonbashi-dori, Chuo-ku, Tokyo. (Ricc Transplanter, Combine, Binder)

Kanriu Industry Co., Ltd.
1526, Hirooka, Shiojiri-shi, Nagano Pref. (Rice Transplanter)

Kioritz Echo Co., Ltd.
11-3, Nishishinjuku 1-chome, Shinjuku-ku, Tokyo. Rice Transplanter, Combine)

Konma Mfg. Co., Ltd
26, 4-chome Izumi-cho, Tsuruoka-shi, Yamagata Pref. (Combine, Binder)

Kubota, Ltd.
22, 2-chome, Funade-cho, Naniwa-ku, Osaka, (Rice Transplanter, Combine, Binder)

Mametora Agricultural Machinery Co., Ltd.
9-37, Nishi 2-chome, Okegawa-shi, Saitama Pref. (Rice Transplanter)

Marumasu Machinery Co., Ltd.
2, Wakasugi, Kamiichi-cho, Nakaniikawa-gun, Toyama Pref. (Rice Transplanter)

Mitsubishi Kiki Hanbai Ltd.
11-15, Higashigotanda, Shinagawa-ku, Tokyo. (Rice Transplanter, Combine, Binder)

Minoru Industrial Co., Ltd.
447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama Pref. (Rice Transplanter)

Noda Industrial Co., Ltd.
3-41, Asahi-cho 5-chome, Takamatsu-shi, Kagawa Pref. (Rice Transplanter, Combine, Binder)

Oshima Agricultural Machinery Mfg. Co., Ltd.
10-17, Teramachi 3-chome, Joetsu-shi, Niigata Pref. (Combine, Binder)

Satake Engineering Co., Ltd.
Ueno 1-19-10, Taito-ku, Tokyo. (Rice Transplanter)

Satoh Agricultural Machinery Mfg. Co., Ltd.
5, 4-chome, Muromachi, Chuo-ku Tokyo (Rice Transplanter, Combine, Binder)

Suzue Agricultural Machinery Co., Ltd.
144-2, Gomen-cho, Nangoku-shi, Kochi Pref. (Rice Transplanter, Combine, Binder)

Toyosha Co., Ltd.
16-5, Joshoji-machi, Kadoma-shi, Osaka. (Binder)

Uemori Agricultural Implement Mfg. Co., Ltd.
Kannonji, Kannonji-shi, Kagawa Pref. (Rice Transplanter, Combine, Binder)

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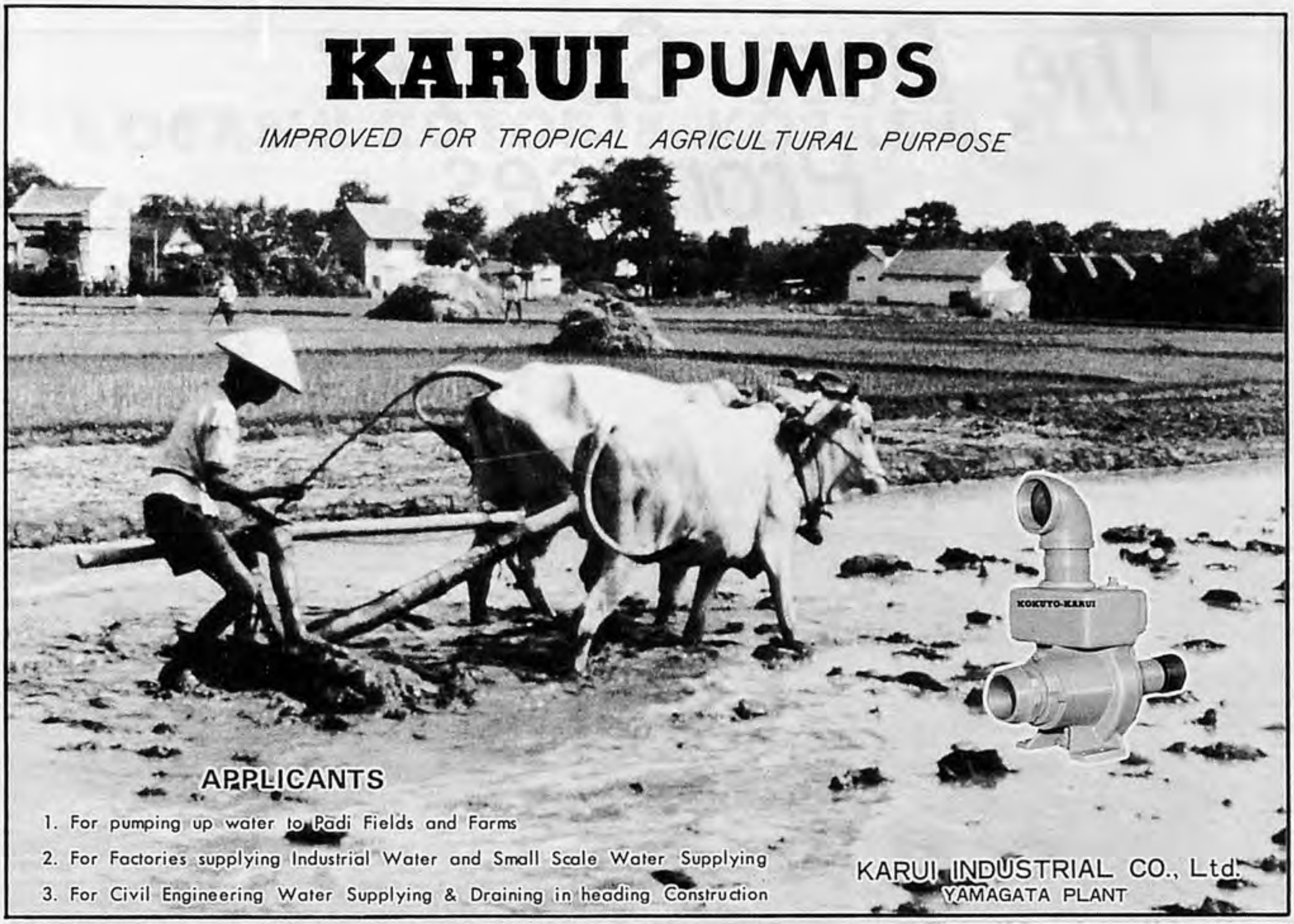
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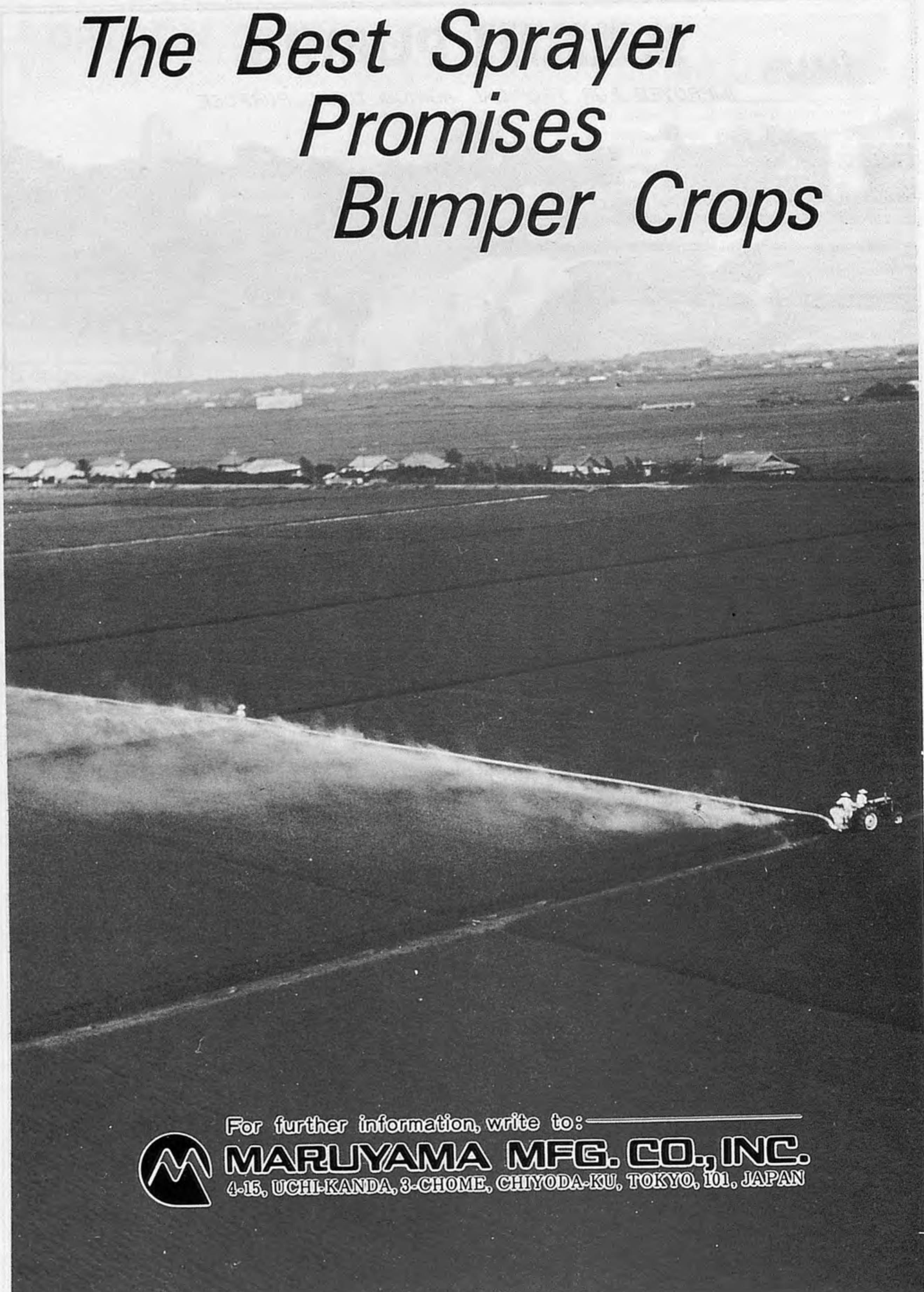
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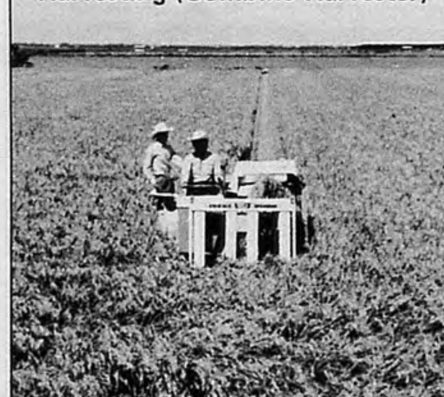
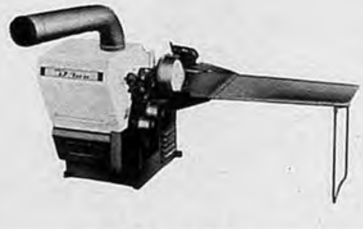
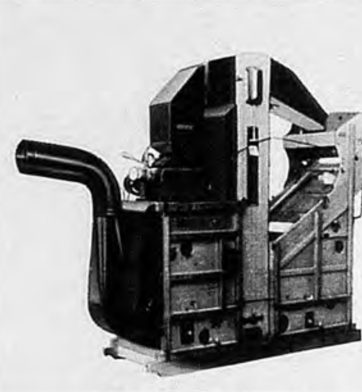


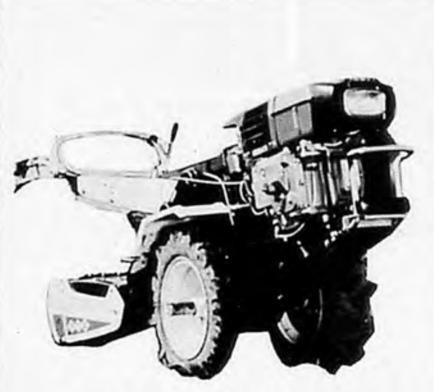
Dryers ITC series



Thresher D series



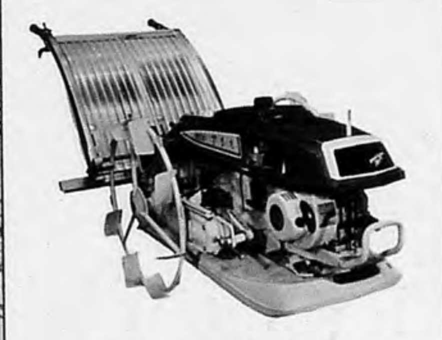
Rice Huller M series



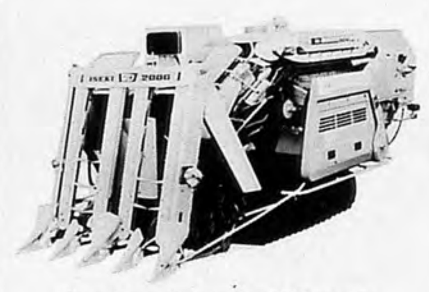
Power Tiller KA series

Power Tiller KS series

Power Tiller KC & AC series



Rice Transplanter



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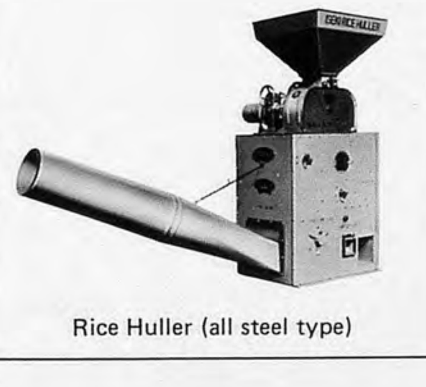
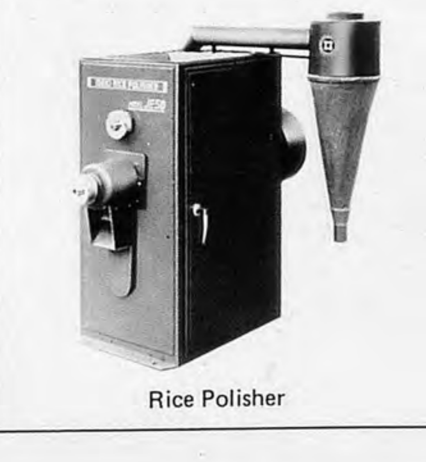


Rice Huller (all steel type)



Rice Polisher