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AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. 3 • NO.2 • Summer '72

Current R & D Activities

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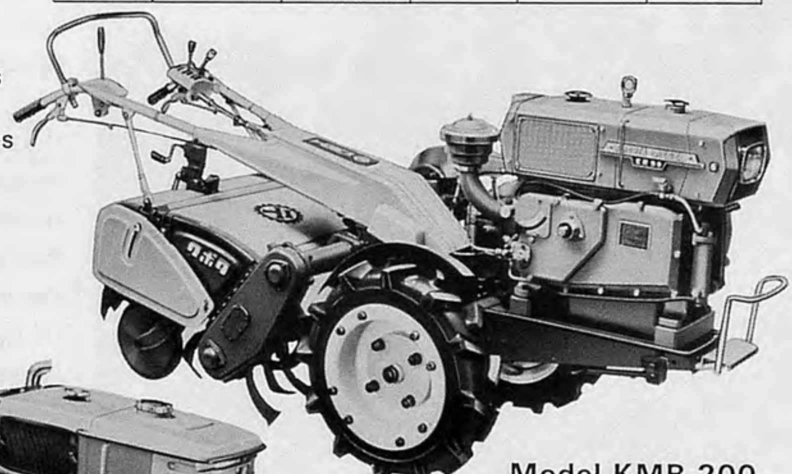
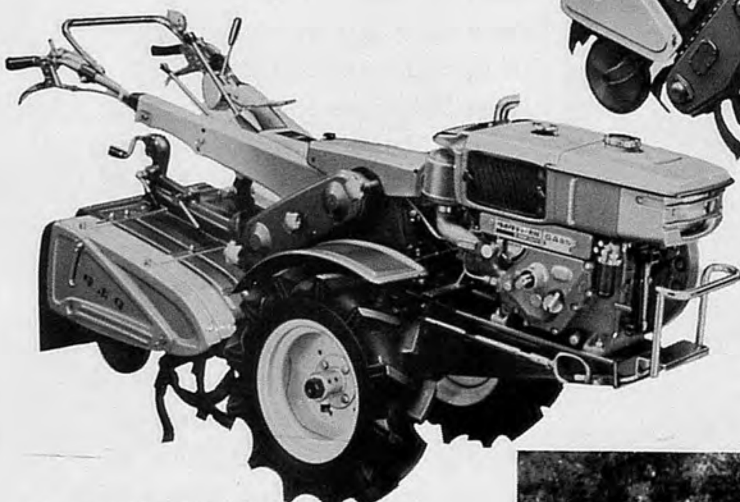
K550	ER50-2	5-6.5HP/ 2,200rpm	Forward 6 Reverse 2	480—600mm	14 pcs.
K700	ER65-2	6.5-8HP/ 2,200rpm	Forward 6 Reverse 2	510—600mm	18 pcs.
KF	KND70	7-9HP/ 1,600rpm	Forward 4 Reverse 1	480—750mm	14 pcs.
	KNDR70L	7-9HP/ 1,600rpm			
KMB200	KND90	9-12HP/ 2,000rpm	Forward 6 Reverse 2	600mm	20 pcs.
	KNDR90	9-12HP/ 2,000rpm			



Model KMB-200



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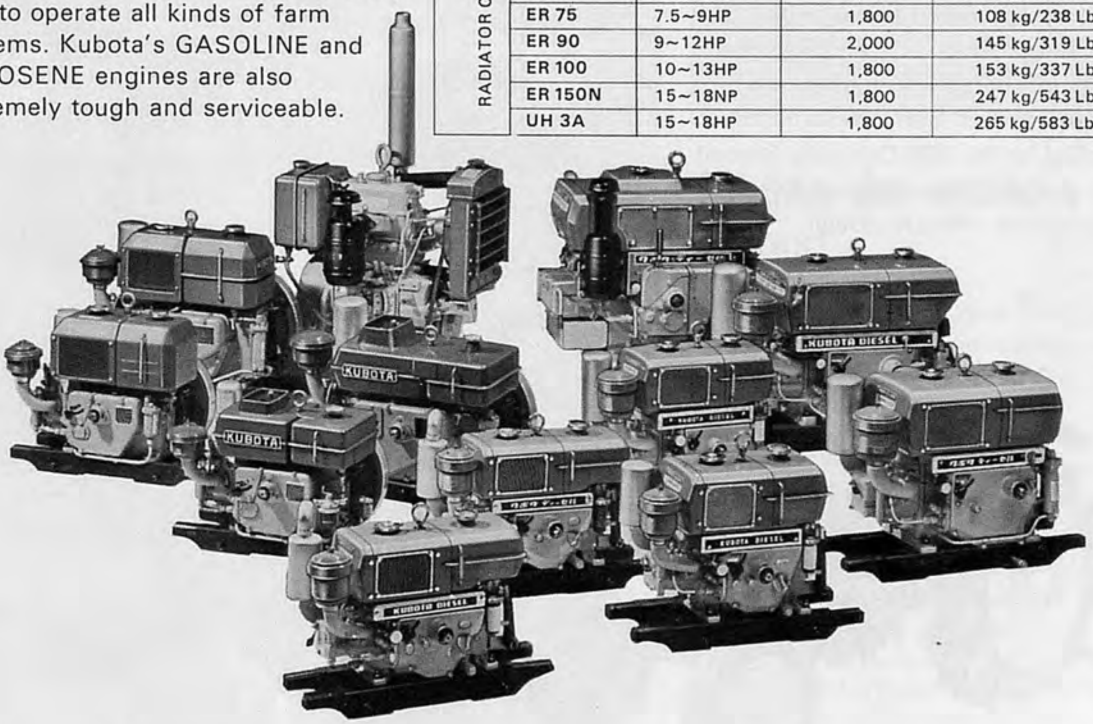
	KND 40	4~5HP	2,000	65 kg/143 Lbs
	KND 5B	5~6.5HP	2,200	75 kg/165 Lbs
	KND 70	7~9HP	1,600	112 kg/246 Lbs
	KND 90	9~12HP	2,000	135 kg/297 Lbs
	KNDR 70L	7~9HP	1,600	100 kg/219 Lbs
	KNDR 90	9~12HP	2,000	145 kg/318 Lbs
RADIATOR COOLING	ER 30	3~3.5HP	2,000	55 kg/121 Lbs
	ER 40	4~5HP	2,000	60 kg/132 Lbs
	ER 50	5~6.5HP	2,200	65 kg/143 Lbs
	ER 65	6.5~8HP	2,200	75 kg/165 Lbs
	ER 75	7.5~9HP	1,800	108 kg/238 Lbs
	ER 90	9~12HP	2,000	145 kg/319 Lbs
	ER 100	10~13HP	1,800	153 kg/337 Lbs
	ER 150N	15~18NP	1,800	247 kg/543 Lbs
	UH 3A	15~18HP	1,800	265 kg/583 Lbs



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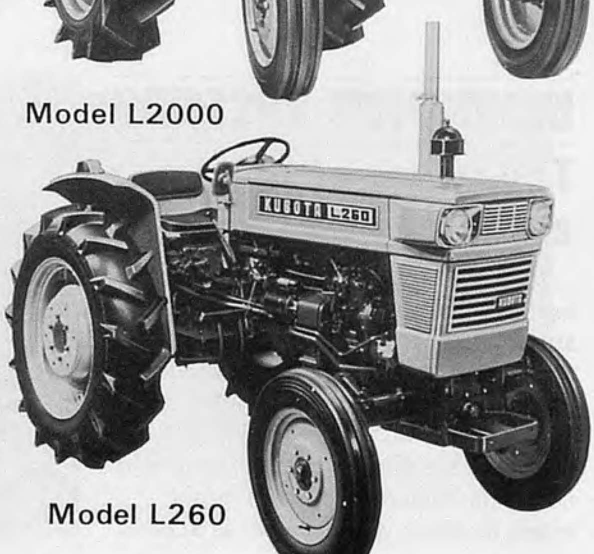
L1500	15 HP	330 mm	597/850/ 1,185/1,371	638 kg/1,400 lbs.
L2000	20 HP	350 mm	576/820/ 1,140/1,430	695 kg/1,529 lbs.
L260	26 HP	370 mm	541/696/ 984/1,266	1,000 kg/2,205 lbs.
L350	35 HP	484 mm	565/1,062	1,440 kg/3,170 lbs.

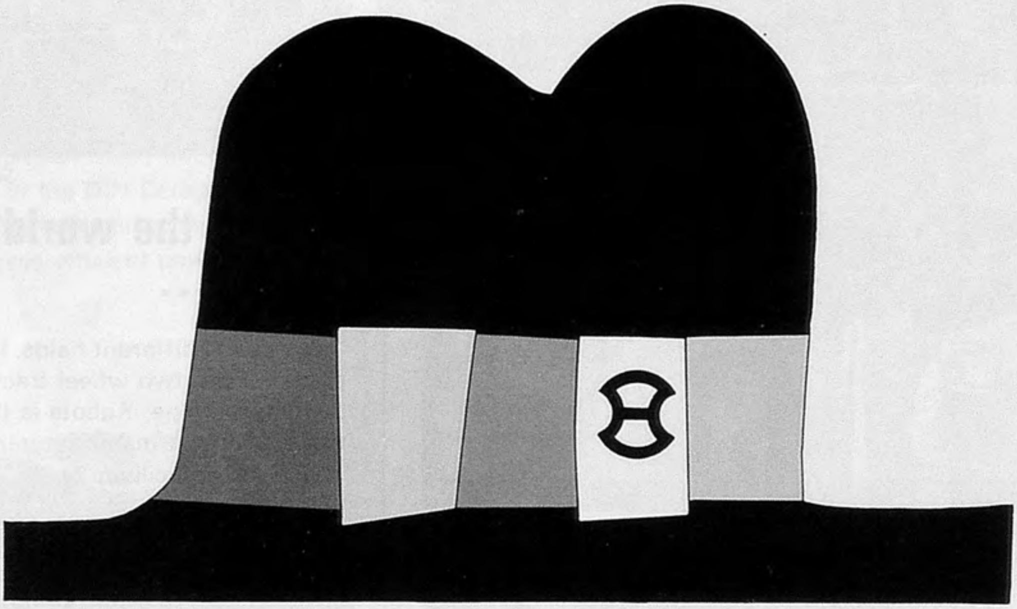
Model L1500

Model L2000

Model L350



Model L260



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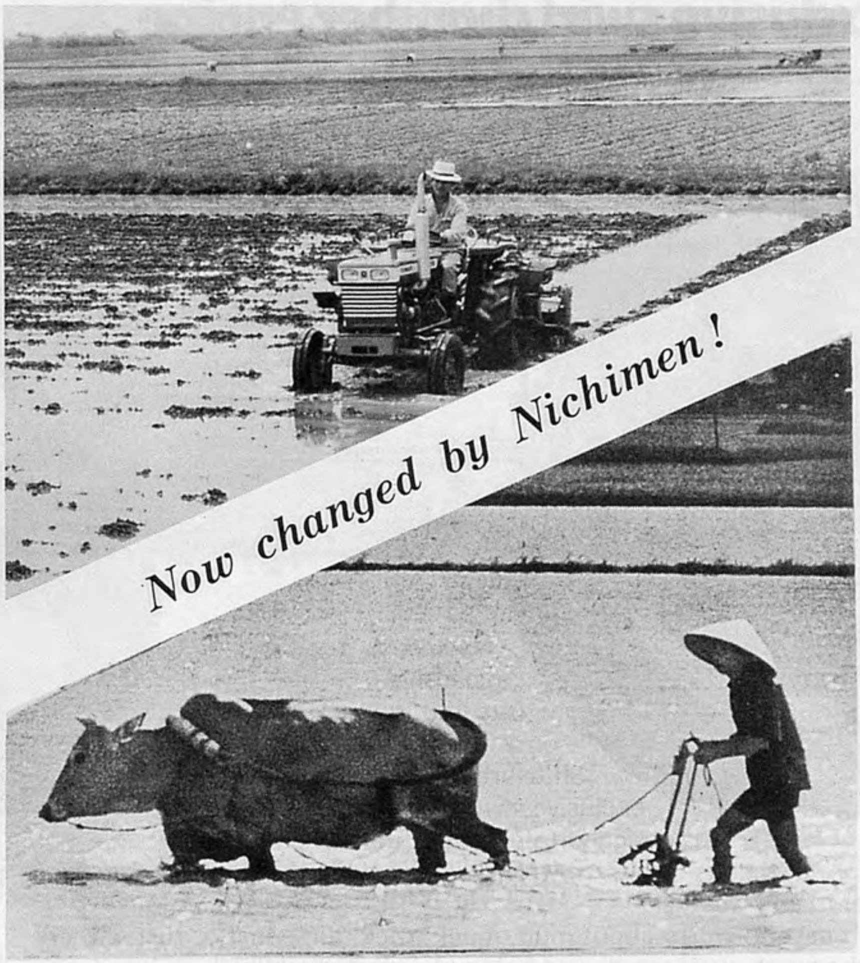

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Preface

R & D is essential factor to promote agricultural mechanization in developing countries. But new development should be finally judged by farmers. New research should be judged whether it can be real power to improve farmers' actual condition by appearing itself as new machines.

R & D activities in the developing countries especially should be taken enough consideration on this point by researchers. Effective link with industry which includes many functions such as marketing, extension, after-service, feedback for improvement and transmitting farmers' need for new machines. This active system like a seed which can grow itself continuously is most essential to be developed.

How can we develope these active system to increase farmers' income continuously? How can we develope the system which continuously create and distribute new machinery in developing countries? Here we found the need for establishing specialized international institute for agricultural mechanization in the developing countries. The main purpose would be to promote developing above-mentioned system at first stage. We can see a good example of these kind of activities at Agr. Eng. Dept. in IRRI where their prototypes are helping to generate new agricultural machinery manufacturers.

In this issue, two papers related to this theme on establishing institute are involved. In last March, ECAFE had the meeting for reporting the Asian industrial development. At that time the experts team's recommendation on the establishing of a regional institute for agricultural machinery was carefully examined. Expert working groupe on "Asian Agricultural Machinery Institute" will hold a meeting at Bangkok from 11 to 13 October, 1972. We expect that really effective institute will be born in the near future.

By the way, new co-editors for AMA project joined us. I am very glad to introduce them to you here. They are Dr. Chancellor, Dr. Esmay, Prof. Khe, Prof. Moens and Dr. Lee. The AMA staffs would like to try to make better link of communication among the professional persons who are engaging in agricultural mechanization problems in the world.

Yoshisuke Kishida

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AGRICULTURAL MECHANIZATION IN ASIA

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AGR. MECHANIZATION and LABOR UTILIZATION in ASIA

by
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The less developed countries of the world are confronted with the question of improving agricultural mechanization that is compatible with the employment situation. Agricultural mechanization in labor surplus countries should and can generate employment as well as increase total food and fiber production. "Mechanization" is defined as including everything from the improvement of hand tools to the introduction of mechanical power units and associated equipment, thus should be a planned continuous program. The questions are if, how, when, and what types of specific tools and machines should be introduced in a given country at a given time.

The mechanization plan should be formulated from a well designed, reliable and through analysis. A basic principle of agricultural mechanization is that it be selective and meaningful (Kline et al., 1969). An introduction of a mechanical aid should fulfill the cultural, employment and humanitarian needs of the society, the production needs of the country, and the economic needs of individual farmers.

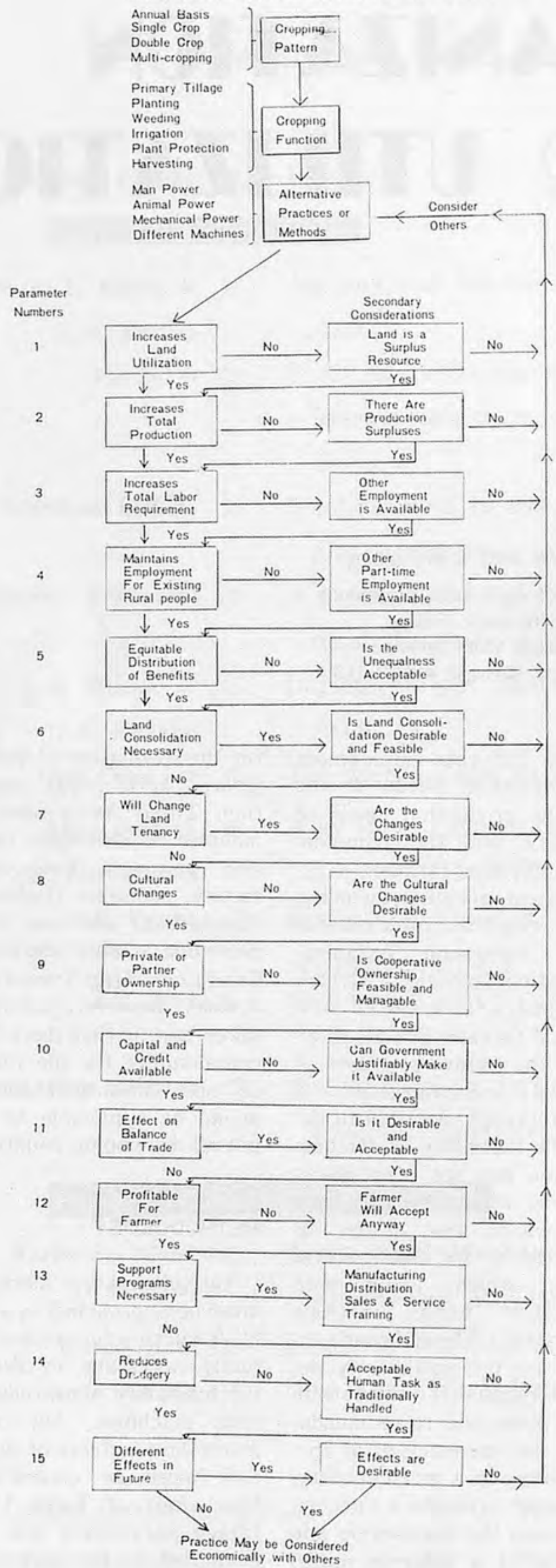
Government planning agencies, research programs, international technical assistance organizations, lending agencies, agricultural engineers, economists, politicians, and farmers are all groping with the many questions of agricultural mechanization. A rational approach designed to determine the feasibility of machine introduction has not been developed. Some attempts have been made towards the design of macro models for agricultural production which, along with many other inputs, include mechanization. These broad approaches are not sufficiently detailed nor reliable for the formulation of plans and recommendations for the introduction of specific machines in a given country.

This paper presents a concept, and discusses the parameters and constraints of a systems model for the evaluation of present and future agricultural mechanization. Three Asian countries are included as examples for discussion purposes. Two are labor surplus countries (Indonesia and Bangladesh) and one (Korea) is becoming a labor scarce country. Conditions differ from country to country, however, the hypothesis taken here is that there is enough commonality for the formulation of one simulation model that would be applicable to many, if not all developing countries.

METHODOLOGY

Agricultural mechanization must be approached systematically. A micro-level analysis is eventually necessary in determining the feasibility of introducing certain machines, but also the macro-level effects of mechanization must be considered. The flow chart of Table 1 presents fifteen parameters that must be evaluated in the formulation of

Table 1. A flow chart for planning agricultural mechanization.



plans and recommendations for the introduction of any tool, mechanical device, machine or power unit.

The sequence of the fifteen parameters of Table 1 is not necessarily in the order of priority or the order in which they might be evaluated in various countries. In any case, the human factors of employment, equitability, cultural effects and drudgery should be considered ahead of detailed cost and return economic analysis for the farm or nation level. Many of the less developed countries are food deficient and limited in cultivatable land resources so these parameters must also necessarily be considered early in any analysis.

The flow chart of Table 1 presents a concept rather than the details of analysis. The systematic evaluation consists of a logical and rational approach that in itself is neutral as to whether any or all mechanization is good or bad. It is impossible to generalize even in a specific country, and say no mechanization should be allowed in order to keep all rural people where they now are and doing the same jobs; or in the converse, blindly accelerate agricultural mechanization to encourage migration to the cities where laborers are needed (at least temporarily) for industrial development.

The evaluation of Table 1 must be applied for each cropping pattern in the various provinces or regions of a country. Various means of accomplishing each cropping function with different machines and power sources must be considered on a micro-level. The micro-level results may be aggregated to a country wide basis for the formulation of major plans. The systematic evaluation of the critical fifteen parameters will provide alternatives and tradeoff information for making management decisions and plans.

There is a secondary consideration for each of the fifteen parameters of Table 1. For example, parameter No. 1; if the practice under consideration does not increase land utilization then move to the secondary consideration. In a given area or country it may be that land is not in short supply. In that case, move from the secondary consideration back to parameter No. 2 pertaining to food production. Likewise, parameters 3 and 4 pertaining to employment would be evaluated differently in labor scarce countries (Korea) as compared to labor surplus countries (Indonesia and Bangladesh). For each parameter, however, if the secondary consideration can only be answered with a "no", that particular method or practice must be evaluated against other parameters on a tradeoff basis. It may be eliminated altogther.

Analytical approaches for evaluating the first four parameters pertaining to land utilization and labor requirements are discussed in this paper for Korea, a labor scarce country with climatic seasons, and Indonesia, a labor surplus tropical country. Parameters 5, 6, 7, and 8 relate to "social costs" and must be evaluated mainly on a macro basis. The next four parameters, 9, 10, 11, and 12 pertain mainly to economic analysis. The secondary consideration of parameter No. 9 with reference to the cooperative ownership approach is discussed in some detail for Bangladesh in the last section of this paper. The fulfillment of the other parameter requirements through the cooperative approach is also included.

Parameter 13 pertains to support programs for mechanization. These are of critical importance. Many mechanization schemes around the world have failed because of insufficient follow through with training, parts, and/or maintenance. Each support program would need a separate paper for any detailed discussion so are not included in this paper. The degree of drudgery must be somewhat of a subjective evaluation so has been included in the latter part of the model as parameter No. 14. The last parameter entitled future effects must be included to some extent in the evaluation of each of the other 14 parameters, but also at this point should be considered on a broad basis to double check for any other effects or trends.

INDONESIA—Land and Labor Utilization

Indonesia, particularly the Island of Java, is a labor surplus(1) and food deficient(2) country with limited resources of cultivatable land and irrigation water. The tropical climate provides a temperature suitable for continuous crop production, however, the availability of irrigation water is the limiting factor outside of the monsoon season.

Labor generation and increased returns per person in the rural areas can be enhanced by increasing the production of each available hectare of cultivatable land. Some new technological inputs must, however, be introduced in order to increase production significantly. Indonesian farmers are presently doing a good job of maximizing rice production with the traditional inputs of indigenous plant varieties, limited humus fertilizers and rain water during the monsoon period.

Rice production can be increased by two to three fold with the introduction of improved varieties, fertilizer application according to plant and soil requirements, controlled water use and adequate plant disease and insect protection. The mature crop must be harvested, removed from the field, dried, stored and transported with a minimum of losses. The critical question for discussion in this paper is whether any improved mechanical aids or machines should be introduced along with selected other new inputs.

The introduction of the new, improved, longer grained rice varieties dictates some changes in the traditional method of harvesting and handling paddy rice in the stalk form(3), or shattering losses may amount to 20 to 25 per cent of the potential crop. These changes involve such things as; harvesting while the grain is still at a high moisture content of 20 percent and above, immediate threshing after cutting and controlled drying particularly during the monsoon season. All of these inter-related functions must be considered with the introduction of new rice varieties, and evaluation of possible mechanical aids for assisting the production and processing phases.

As indicated by the flow chart of Table 1, land and labor utilization should be evaluated during the first phases of considering the introduction of any mechanical device. Figures 1 and 2 present the graphical results of an analysis designed to compare man power, animal power, and mechanical power for various rice production functions (Esmay et al., 1971). Figure 1 shows annual labor requirements for producing rice continuously on one hectare of land. Figure 2 shows the portion of time the hectare of land is utilized with a growing crop.

The following assumptions were made for this analysis:

1. Optimum water supply and control for year round rice production.
2. Optimum weather conditions for year round rice production.
3. One crop of rice required 120 days regardless of the time of year.
4. Abundance labor was assumed for all man-power operations.

The variables presented in the graphical analysis of Figure 1 and 2 only pertain to the cropping functions that must be per-

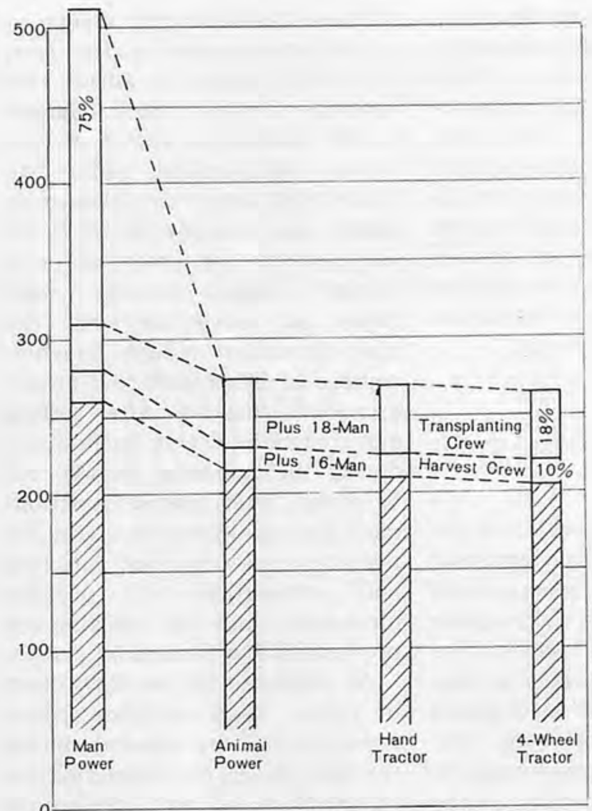


Fig.1. Labor Utilization for One Hectare of Continuous Rice in the INDONESIA

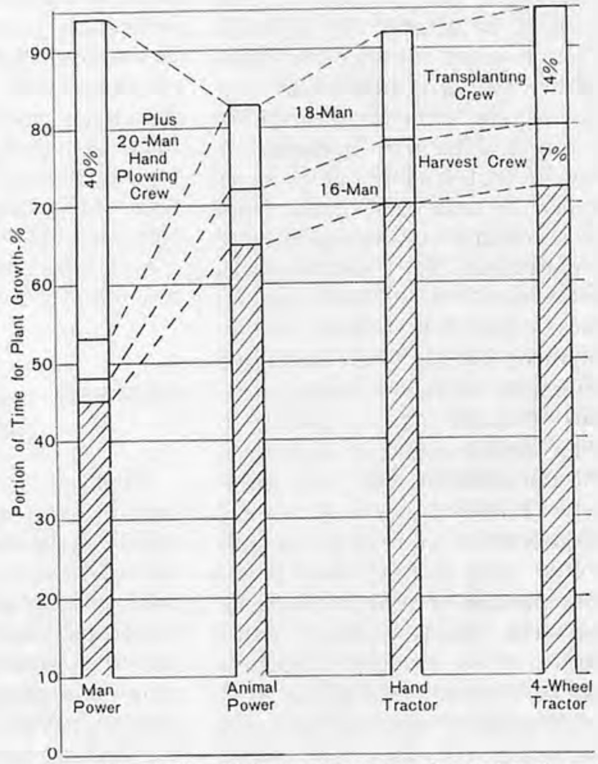


Fig. 2. Land Utilization Efficiency for One Hectare of Continuous Rice in the INDONESIA

formed in the field between crops of rice. These are basically land preparation, transplanting, and harvesting. All other labor consuming practices have little, if any, effect on land utilization so timeliness is not important in this respect. Timeliness may be important, however, for increasing yields and decreasing losses.

The cross hatched portion of the bars of Figures 1 and 2 represent a one-man operation for one hectare of rice production. The man days of labor per hectare per year include hand labor for all rice production functions. The labor data used is not totally representative of Indonesia so a breakdown is not given in this paper. The data are indicative enough however, to present the concept of labor and land utilization anaylsis. An actual feasibility study of mechanization for Indonesia must be based on reliable and accurate data.

The shaded bars of Figure 1 show man power (all hand operations) utilizing about 50 man days more labor per hectare per year than when animal or mechanical power was used for primary tillage. Figure 2 shows the comparative land utilization factors which explain the somewhat nominal labor utilization advantage of about 50 man-days per year per hectare. Animal and mechanical power for primary tillage increased the land utilization from 45% of the year to about 70%. This also means more crops of rice and more annual rice production.

The first increment above the shaded bars of Figures 1 and 2 represents what would happen by using a 16 man harvesting crew instead of just one man. The second increment is an 18 man transplanting crew. The size of crews shown here is arbitrary. The harvesting and transplanting crews complete each of these production functions for one hectare in a couple days; thus, there are significant improvements in land and labor utilization. The rice producing peasants of Indonesia know this, as it is exactly how they do it where there is abundant hired labor. This concept then shows a way of quantifying, comparing and explaining the production operations.

The somewhat more radical effect is shown by the third increment on the man-power bar, which represents the introduction of a 20-man hand-labor crew for primary tillage (plowing with the traditional short handled hoe). The labor crew approach to land preparation brings the land utilization factor up to that of animal or mechanical power and nearly doubles labor utilization in man days per hectare per year. This makes it evident that if hand labor is available for the large crew approach it is truly a labor generative operation without sacrificing land utilization. Total production may be sacrificed some by the hand primary tillage unless it can be substantiated that resulting yields are equivalent to those for animal or mechanical power land preparation. Animal power looks a bit low in this analysis because only one animal pulled plow was assumed for the one hectare. Two or three animal plows could be used and the overall land utilization factor would then be as high as the other power sources.

At least in parts of Indonesia the transplanting and harvesting operations are traditionally done by large crews of laborers (mostly women). The farmers thus recognize that they can benefit by hiring large labor crews so they can get another crop of rice growing as soon as possible. The use of large crews of laborers for primary tillage with the traditional short handled hoe does not seem to be customary in Indonesia. Family male members appear to be the only laborers in the individual paddy fields doing primary tillage. Hand hoeing is hard work and evidently not traditionally done by women. This elimination of one-half of the potential work force possibly brings about some shortage of labor for the land preparation phase of rice production.

The model of Figure 1 and 2 exhibits considerable sensitivity to the variation in labor unit input and types of power for primary tillage. An evaluation of this type could be used quite effectively to determine what labor input and type of power for primary tillage would be necessary to develop a certain land utilization index. For example, if plans were being made for the production of three rice crops per year. The growing period for each can be predicted and the total might, for example, dictate that a land utilization index of 85 percent must be attained. This would leave 15 percent of the 365 days of the year (55 days) for the land preparation, transplanting and harvesting of the three crops. Various combinations of labor crew sizes and/or animal or mechanical power for primary tillage could be determined to meet the constraints.

KOREA—Labor and Land Utilization Efficiency

A shortage of rural labor is developing in South Korea, particularly during the double cropping peak labor requirement periods for rice and barley harvesting and transplanting in the southern provinces. Farm hired labor wages increase about 25 to 30 percent during these seasonal peak labor requirement periods, and the average hourly or daily cost of hired labor has been rising more each year than any other production cost. The limited rural labor situation has been brought about by a booming industrial sector and a static agricultural sector. The migration of rural people to the cities has, thus been stimulated. The movement of young people to the cities has been most prominent.

The limited availability of rural labor suggests a need for some type of mechanization to minimize labor requirements during the seasonal peak periods (Korean Government, 1971). South Korea must also increase the production of food grains as they now fall about 25 percent short of fulfilling consumption needs. If mechanization is to be most meaningful and beneficial for the country, then increased production must be a major objective along with increased efficiency of the farmer in accomplishing the peak period cropping functions. Any mechanization must, of course, be economical and operational within the conditions of the country. The question at hand then, is what kind of an analytical approach can be made to determine the feasibility of selectively introducing machines at some optimum rate over the next 5, 10 or 15 years.

The analysis of mechanization for South Korea (a labor scarce country) must consider the same parameters (See Table 1) as for Indonesia (a labor surplus country) although the constraints placed on the various parameters are different. For the evaluation of parameters 1, 2, 3, and 4 of Table 1 for Korea an analytical approach is discussed and presented graphically in Figure 3. The concept of this micro-level analysis was suggested by Lee Jeung Han, 1971 and parallels that of Table 1 in that it pertains to a specific cropping pattern in a given climatic area. Various alternative practices and mechanical operations are considered for the required cropping functions. The symbolic labor requirements, as presented in Figure 3, are included in this paper for discussion purposes only. The analysis must also be carried on through evaluation of the other 11 parameters of Table 1. If none of the social cost parameters eliminate a given machine then the economic analysis is undertaken. This would include the parameters from No. 9 through 12.

The traditional man/animal agricultural cropping functions must first be studied. Labor requirements for each function must be determined and distributed into ten-day periods throughout the year. Figure 3 presents a graphical summary of one hectare labor requirements throughout the year for a double cropping (rice/barley) pattern in one example Korean province (Lee Jeung Han, 1971) (Kim Song Ho, 1970). The ten-day period labor totals were arrived at by first determining optimum planting, harvesting and other cultural practice dates for the two crops. From the cropping dates, time periods were set up for the accomplishment of specific tasks; and labor requirements for each function were distributed by

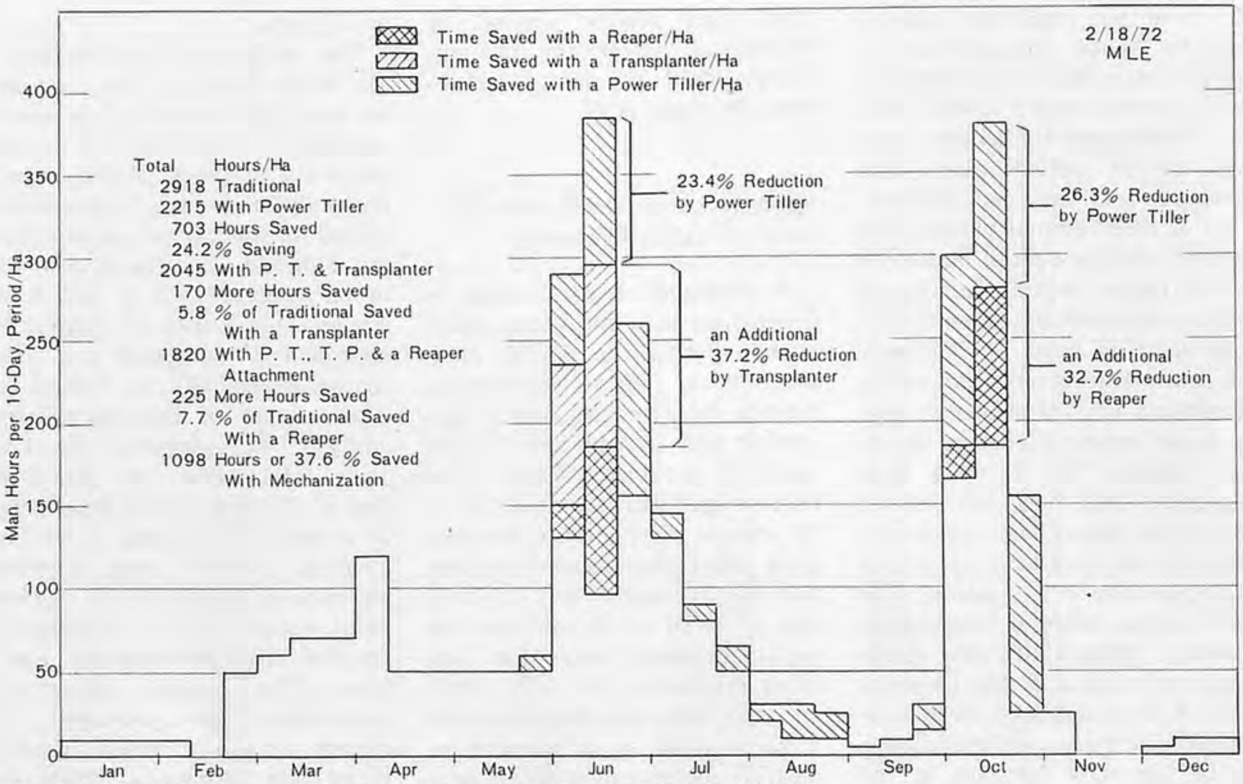


Fig. 3 Rice/Barley Traditional Man-Animal Labor Requirements-Chang Chan Nam Do, KOREA

10-day periods.

The graphical presentation of Figure 3 emphasizes the severity of the two peak labor requirement periods for double cropping in the Chang Chan Nam Province of South Korea. The middle ten days of June and October each have labor requirements of four men working ten hours per day during all ten days.

The peak labor requirements are so critical that many farmers may choose not to attempt double cropping of barley with their rice crop. The climatic conditions of this province just barely allow the growing of two crops; thus, the cropping functions of barley harvesting, primary tillage and rice transplanting are squeezed into a short period in June and rice harvesting, primary tillage and barley planting squeezed into October. Barley is a low value crop compared to rice so the farmers don't want it to interfere or adversely affect the yields of their rice crops.

Mechanization for Korea should be designed to reduce labor requirements during the two peak periods and to accomplish the cropping functions quickly in order to make double cropping more economical. The shaded portions of Figure 3, presents the labor saving potential of some specific machines. Reliable machine performance data under Korean conditions for the three critical functions of primary tillage, rice transplanting and harvesting must be utilized. The use of a power tiller, for example, as represented in Figure 3 for primary tillage may reduce the labor requirements about 25 percent for each peak period (Institute of Agricultural Engineering, 1971). Similar performance data for a push type mechanical transplanter indicate that it may reduce the June peak labor requirement another 37 percent. Likewise, a reaper may reduce the October peak labor requirement by 33 percent.

The economic feasibility is equally important to the machine performance and labor reduction. To make the feasibility study complete, all possible power units and machine types must be considered. This should include different sizes and kinds of power tillers along with 4-wheel tractor power units. Also, self-propelled transplanters, binders, and combines should be included.

BANGLADESH—a Machine Cooperative Case Study

Bangladesh, formally the province of East Pakistan, is somewhat similar to the Island of Java, Indonesia, in so far as population density(4), and farm size are concerned. The industrial and service sectors in Bangladesh offer almost no opportunity for employment of persons that might leave agriculture. Any form of agricultural mechanization must not then displace rural labor and stimulate migration to the cities.

Table 2 shows that over 40% of the families are landless or near landless (less than 0.8 acres). In 1969, more than 70% of the

Table 2. Land holdings of agricultural families.

Land Holdings	% of Families
no cultivatable land	15
0.01-0.8 acres	26
0.81-2.0 acres	28
2.01-4.0 acres	18
4.01-6.0 acres	8
over 6.0 acres	5

rural families in the Comilla Thana (County) felt that they were unable to maintain current standards of living (Myeed, 1969). Employment opportunities for the small farmer with less than two acres and the landless seems to be crucial in preventing migration from the rural areas.

Rice is the major crop grown in Bangladesh and accounts for approximately 80% of all crop land. The family and hired labor utilized in the production of improved and non-improved varieties of rice is shown in Table 3.

Table 3 indicates that except for tillage the number of mandays of labor per acre for each operation was greater when improved varieties of rice were grown, than when non-improved varieties are grown. The total labor required to grow improved rice, averaged 75.39 man-days per acre which was a 48% increase over the 50.89 man-days per acre average in growing non-improved varieties. Table 3 also indicates that except for tillage the proportion of labor that was hired was greater when improved varieties were grown than when non-improved varieties are grown. An average of 60.25 man-days/-acre of hired labor,70% of the total, was used in growing improved rice varieties compared to 30.50 man-days/acre of hired labor, 60% of the total, when non-improved rice was grown. The use of family labor was not significantly different, 20.4 man-days/acre when non-improved varieties were grown and 22.6 man-days/acre when improved varieties were grown. The increased labor used in growing improved varieties came almost entirely from hired labor. This differential in hired larbor was significant at the 5% level. Experience in the Comilla Thanna indicated that improved varieties were grown equally successfully by both small and large farmers (Faidley et al., 1971). Thus, improved varieties meet both requirements; labor generation and benefits to small farmers. The development of methods to increase the uses of improved rice varieties should therefore be encouraged.

IRRIGATION

Traditionally, Bangladesh has practiced a monsoon agriculture. Crops were grown during the monsoon season from March to September. The land then remained fallow the rest of the year. Mechanical irrigation, however, has allowed the growing of an additional crop during the dry winter season. Since improved varieties of rice were available for use during this irrigated season, labor generation has been dramatic. In the Comilla Thana mechanically irrigated acreage during the winter season increased from 1147 acres in 1965 to over 8500 acres in 1970 (Faidley et al., 1971). Hired labor use due to mechanical irrigation increased from 35,000 man-days in 1965 to over 450,000 man-days in 1970.

The benefits resulting from mechanical irrigation have been well distributed in the Comilla Thana. The main reason for this is that the pumps and wells were controlled by village cooperatives and not by individual farmers. Cooperatives were necessary because of the small fragmented land holdings of individual farmers. Only non-cooperative farmers with less than 1.0 acre were consistently represented in winter irrigation in a smaller proportion than they were in the total rural

Table 3. Family and hired labor utilization in rice production.

	Mandays of labor	% of labor		% of total hired labor in each operation	% of total family labor in each operation	% of total labor in each operation
		Hired	Family			
Tillage						
Improved rice	4.75	28	72	2	15	6
Non-improved rice	5.80	30	70	5	18	11
Fertilizer						
Improved rice	6.00	66	34	8	9	8
Non-improved rice	5.05	61	39	8	8	8
Transplant						
Improved rice	18.00	83	17	28	15	24
Non-improved rice	17.52	78	22	41	19	32
Feed						
Improved rice	20.53	74	26	29	24	28
Non-improved rice	13.26	63	37	15	14	15
Insecticide						
Improved rice	1.92	44	66	1	4	2
Non-improved rice	1.23	31	69	1	2	1
Harvest						
Improved rice	15.23	82	18	23	13	20
Non-improved rice	13.16	68	32	27	20	24
Threshing						
Improved rice	8.96	51	49	9	20	12
Non-improved rice	4.87	18	82	3	19	9
Total						
Improved rice	75.39	70	30	100	100	100
Non-improved rice	50.89	60	40	100	100	100

population (Faidley et al., 1971).

In summary, mechanized irrigation has both increased labor utilization and had its benefits successfully distributed to all segments of the rural population. Mechanical irrigation has been the most successful form of mechanization for increasing the intensity of land use in Bangladesh.

TILLAGE

Tillage in Bangladesh has traditionally been performed by a pair of bullocks working with a wooden plow. Essentially, no tillage has been performed by a man and a hoe. Farmers without bullocks rented them from other farmers. In the Comilla Thana only 8.2% of the farmers with less than one acre and 26% of the 1 to 2 acre farmers owned a pair of bullocks in 1964. Thus, the large majority of small farmers depended upon renting the source of power to perform their tillage.

The Comilla Thana attempted to supplement the bullock power by introducing 35 hp tractors. The tractors were owned by a central cooperative association and rented to groups of farmers through the local village cooperatives. Tractors reduced the total time required for tillage from 11.92 days/acre when bullocks were used alone to 5.45 days/acre when tractors were used in addition to bullocks (Faidley et al., 1971). Bullocks were not completely replaced in the tillage operation since tractors were used only for initial tillage and bullocks were still used for a final leveling and puddling of the soil before the crop was planted.

The human labor required for tillage was 6.18 man-days/acre when only bullocks were used and 3.16 man-days/acre when tractors supplemented bullocks. Table 2 indicated that over 70% of the labor used in the tillage operation was family labor. Tillage provided only 2% and 5% respectively, of the total hired labor used in growing improved and non-improved rice. Thus, hired labor use in tillage was small. Any reduction due to tractor use would be negligible in comparison to total hired labor requirements. Actually, persons using tractors used more total hired labor. Persons using the tractors hired 56.45 man-days/acre of labor compared to 51.78 man-days/acre for bullock users when improved varieties of rice were grown and 35.75 man-days/acre compared to 34.49 man-days/acre when non-improved varieties were grown. In the Comilla Thana, tractor mechanization neither significantly increased nor decreased hired labor. Therefore, based upon a criterion of labor displacement, tractor mechanization can be neither justified nor rejected.

The second criterion, the benefits of tractor mechanization to the small farmers will next be considered. The distribution by farm size of persons using tractors for tillage and those using only bullocks for tillage indicates that 57.4% of all tractor users had farm sizes of less than 2.0 acres, while 53.5% of the bullock users had farms of less than 2.0 acres. Thus, a larger proportion of the tractor users had small farms than did bullock users. One reason for this is that 83% of the rice growers who did not own bullocks had farms of less than 2 acres. Of the farmers without bullocks, 49% used the tractors. Thus, the tractors were an important power source for the small farms without bullocks. In addition, during the irrigated season the farmers without bullocks who used the tractors cropped a larger proportion of their farms, 60% compared to 47% for those who rented bullocks. For farmers who owned bullocks, the proportion of their farms which was cropped was nearly equal when bullocks were used for tillage, 48%, as when tractors supplemented the bullocks, 49%. Thus, the tractors have benefited the small farmers without bullocks who owned, on the average, 1.35 acres of land, by increasing his cultivated acreage.

In the Comilla Thana tractors have apparently filled a power shortage for the tillage operation. Between 1965 and 1969 when the tractors were gaining a fairly widespread use, the value of livestock and, therefore, the number of work animals on farms measured in constant prices remained constant. Thus, farmers continued to own bullocks even though they supplemented this source of power by renting the tractors. The inadequacy of bullock power was especially apparent during the winter irrigation season of 1969 when 25% of the rice growers who owned bullocks also rented the tractors to help perform their tillage.

■ ■

This paper was prepared for the Annual ASAE Meeting in Hot Spring, Arkansas, June 30, 1972.

(1)There are approximately 66,000,000 people in Java living on 132,174 sq km of land. This is a density of 500 people per sq km (1290 people per sq mile). Food crops can be raised on only 6% of the land.

(2)In 1969-70, 10.5 million metric tons of rice were produced on 7.6 million hectares for an average of 1358 kg/ha. The five-year plan sets a target of 15.4 million tons of 1974.

(3)Traditionally, paddy rice is harvested in Indonesia by cutting the stalk 15 to 20 cm below the head. This stalk paddy is gathered into small hand carry sized bunches of 2 to 4 kg each. The stalk paddy is thus transported, dried, stored, and often times marketed in this bunch form.

(4)Bangladesh has 1300 people/sq mile and 95% of these people derive their livelihood from the rural areas. Throughout the 1960's the population growth rate was 2.5%/year.

STUDY and DISCUSSION on Several Problems for Farm Mechanization in Developing Countries

(Part One)

Analysis on Market Price Concept of Imported Farm Machinery in Developing Countries

by
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A. Commercial Basis Marketing Network

Considering Sales and Service Networks of farm machinery from the viewpoint of import, there are many ways of distribution order from production manufacturers to farmers. Some of them in the market of free nations are as follows:

1. Manufacturer—Exporter—Importer—Wholesaler—Retailer
2. Manufacturer—Trading Company—Sole Agent—Retailer
3. Manufacturer (including Export Department)—Sole Agent (including Import Department)—Retailer

Number 1 has many middlemen, so that, Number 2 is the usual network in case of Japanese manufacturers. The simpler method of Number 2 is Number 3, which is the shortest network to produce lower retail price in general. Number 3 requires, however, bigger capital and systematic abilities in management to both manufacturers and sole dealers.

The price structure in case of Number 2 will be calculated herein as a conceptional example. Generally, Manufacturer Price is the price added Cost of Production A and Margin.

Production cost A consists of two costs as shown in **table 1-1.** The margin of a manufacturer is divided into three groups as shown in **table 1-2.**

Then, if α is the marginal percentage of a manufacturer to the production cost A, manufacturer price B to the trading company is:

$$B = A + A\left(\frac{\alpha}{100}\right) = A\left(1+\frac{\alpha}{100}\right) \qquad (1)$$

The trading agency (company) who bought a machine at price B will then, sell the machine at FOB (Free On Board) price in general. (There are several Trade Terms in this stage depending on trading condition among them. There are FOB, CIF, C & F and so forth, The FOB is the price of the machinery that is accommodated, in other words shipment, on a cargo freight or boat at exporting harbours. CIF price includes ocean freight and insurance to importing harbours. FOB payment from importing side is better than CIF payment for official holding of foreign exchange in the importing country to save foreign exchange.

Production Cost A

- **Direct cost**
  - Direct materials, Parts, Wages for outside order, Direct labour, and Others
- **Indirect cost**
  - Indirect Materials, Indirect labour, Welfare, Depreciation, Rent, Insurance, Repair expenses, Power rate, Gas rate, Wate rate, Traffic and Others

Table 1-1 Contents of Production cost.

Margin

- **Sales & service cost**
  - Pay for sales & service men, Traffic, Correspondence, Freight rates, Packing charges, Articles of consumption, Advertisement, Entertainment and Others
- **Management cost**
  - Pay for executives, Pay for office workers, Charge for board, Welfar, Interest, Depreciation, Taxes and Others
- **Profit**

Table 1-2 One example of margin

Then, the selling price C which is the FOB price of the trading company to the sole agent will be,

$$C = A\left(1+\frac{\alpha}{100}\right) + A\left(1+\frac{\alpha}{100}\right)\left(\frac{\beta}{100}\right)$$

$$C = A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) \qquad (2)$$

Where: β is the marginal percentage of trading company to price B. (Margin is the difference in price between buying and selling.)

Then, in usual case, a sole agent has to open L/C (Letter of Credit) of price C to the trading company. However, the sole agent has also to pay ocean freight f, and insurance of shipping i, to the shipping and insurance companies respectively. Besides these, in general, the sole agent has also to pay an import duty or import tax Ti. Thus, the total payment D of the sole agent would be,

$$D = C + f + i + Ti$$

$$D = A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i + Ti \qquad (3)$$

Note: $(C+f+i)$ is the CIF price

Now in the next stage, a sole agent has to sell the imported machine of price E, that consists of price D and the margin of the sole agent, to expect perfect sales, service activities and profit. Actually, this margin includes a complicated middle expenses such as wharfage, handling, freight-in, brokerage charges, commissions, warranty, warehouse fee, etc. Therefore, price E is

$$E = \left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i + Ti\right\}\left(1+\frac{\gamma}{100}\right) \qquad (4)$$

Where: γ is the marginal percentage of sole agent to price D.

Thus, the resulting price F includes margin necessary or needed by the Retailer to price E.

$$F = \left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i + Ti\right\}\left(1+\frac{\gamma}{100}\right)\left(1+\frac{\mu}{100}\right) \qquad (5)$$

Where: μ is the marginal percentage of Retailer to price E

Sometimes in a large country, Main-dealer is established between a sole agent and the retailer, who is sometimes called Sub-dealer, in order to have a better service and sales network.

B. Import Tax (Ti), and other Taxes:

Many types of tax % ti are established depending on the country, sort of machine and sort of original price to be taxed. Common method of tax indication is percentage to CIF price. Then, Ti can be calculated as,

$$Ti = CIF \times \frac{ti}{100}$$

$$Ti = \left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i\right\}\frac{ti}{100} \qquad (6)$$

Substituting Equation 6 into Equation 5, the result is :

$$F = \left[\left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i\right\} + \left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i\right\}\frac{ti}{100}\right]\left(1+\frac{\gamma}{100}\right)\left(1+\frac{\mu}{100}\right)$$

$$F = \left\{A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{\beta}{100}\right) + f + i\right\}\left(1+\frac{ti}{100}\right)\left(1+\frac{\gamma}{100}\right)\left(1+\frac{\mu}{100}\right) \qquad (7)$$

Table 1-3 shows the percentage of import tax to the CIF price in several countries. In some cases in importing countries, sales tax ts% is to be added to sales activities.

Table 1-3 Import Tax of Selected Countries (% to CIF Price)

Country	Hand Tractor	Riding Tractor	Rice Polisher	Rice Thresher	Rice Huller
Indonesia	10	10	10	10	10
Philippines	5	5	20	10	10
Malaysia	4	4	4	4	4
Taiwan	13	13	13	13	13

By Sakai, 1972 April

C. Ocean Freight and Insurance Expenses

These expenses are usually depending on the kind of goods and the distance travel during the delivery. Insurance is comparatively small to the FOB price.

The ocean freight is mainly estimated from the calculation of weight and measurement, so called W/M method. Small but heavy items like iron mass, will be estimated by its weights, i.e., ton, while light but large size package will be by its volume, i.e., cubic feet. The distance travel between the export and the import harbour is not a big factor to the ocean freight. Actual fee from Japan to Southeast Asian countries are usually less than $1.00/cubic foot and $20.00/ton. The actual price of FOB and CIF across the Pacific Ocean are shown in **table 1-4.**

The calculated % ρ of ocean freight and insurance expenses to FOB was around 5% or less in case of about $300 to $600 FOB price.

Then, using ρ, Equation 7 can be conceptionally changed as follows:

$$f + i = A\left(1 + \frac{\alpha}{100}\right)\left(1 + \frac{\beta}{100}\right)\frac{\rho}{100}$$

Substituting this equation into Equation 7, will be

$$F = A\left(1 + \frac{\alpha}{100}\right)\left(1 + \frac{\beta}{100}\right)\left(1 + \frac{\rho}{100}\right)\left(1 + \frac{ti}{100}\right)\left(1 + \frac{\gamma}{100}\right)\left(1 + \frac{\mu}{100}\right) \qquad (8)$$

Equation 8 is available to calculate conceptional retail price F of an imported farm machine from following factors:

$\alpha, \beta, \gamma, \mu \cdots$ margin percentage in each stage

ti………… percentage of import tax to CIF price

ρ………… percentage of freight and insurance to FOB price

Demonstrating Power Tiller

D. Margin in Each Stage

Manufacturers' margin consists of necessary expenses for sales and service activities and profit including investment for next production and development of new machines. The margin of trading companies consists of sales and service expenses supported by information activities and profit. The margin of sole agent and retailer consists of profit, necessary expenses for sales and service activities including several comission to middlemen to have special sale promotion, transport-in, warehouse fee, stocking of servicing parts, factories for repairs and maintenance, etc.

Table 1-4 Estimated FOB and CIF from Japan to the West in the United States*

FOB	Ocean Freight f & Insurance i across the Pacific (1971)	CIF	(f+i)/FOB (Per Cent)
62.30	6.50	68.80	10.4
110.00	9.00	119.00	8.4
126.00	9.00	135.00	7.3
117.00	9.00	126.00	7.7
138.00	9.00	147.00	6.5
150.00	9.00	159.00	6.0
153.00	9.00	162.00	5.9
163.00	9.00	172.00	5.5
147.00	9.00	156.50	6.1
155.00	10.00	165.00	6.4
251.00	12.00	263.00	4.7
302.00	11.00	313.00	3.7
272.00	15.00	287.00	5.5
316.00	16.00	332.00	5.1
355.00	16.00	371.00	4.5
353.00	16.00	369.00	4.5
500.00	20.00	520.00	4.0
577.50	19.50	597.00	3.4
411.00	20.70	431.70	5.0
577.50	19.50	597.00	3.4

*Courtesy of Trading Company, Japan to the author.

In case of farm machinery, expenses for post-sales service to farmers should be so perfectly prepared as to stock parts and to keep machines, service facilities and networks ready against trouble.

The marginal percentage of each stage should be naturally decided with competitive consideration done by the seller to get higher sale activities in the free market. Thus these margins are usually changeable in each stage.

A characteristics of marginal percentage of farm machinery as a rule is like this: "the bigger the quantity of sale, the smaller the marginal percentage."

In several books, marginal percentage in each stage is expressed as the per ct. to the retail price F, resulting in complicated per ct.

In this analysis, percentage in each stage means the values to purchase price in each stage.

Thus, through my own experiences and marketing survey, the marginal percentages of a certain goods in each stage to perchase prices can be considered almost similar values. For example, the marginal percentage α, γ and μ for the farm machinery of mass production are approximately 15% to 25% each in domestic market. However, in case of export model machines, they will become easily 25% to 30% or more because of special package expense of long distance travel, special sale and service job for small quantity sale and so forth.

E. Retail Price Concept of Imported Farm Machine in Developing Country for Production Cost A in Advanced Country:

Utilizing the above mentioned equation for F (Eq. 8) with conclusion of every factor in the equation, the buying price F of a farmer in the developing countries for a certain farm machine which is produced in an advanced country with a production cost A of just100 will be calculated as an example.

If marginal percentage α, β; γ, and μ is equal to 25% each (Least margin), and import tax% ti is 5% and ocean freight and insurance % ρ is 5%, then:

$$F_1 = 100\left(1+\frac{25}{100}\right)\left(1+\frac{25}{100}\right)\left(1+\frac{5}{100}\right)\left(1+\frac{5}{100}\right)\left(1+\frac{25}{100}\right)\left(1+\frac{25}{100}\right)$$

$$=100(1.25)(1.25)(1.05)(1.05)(1.25)(1.25)$$

$$\fallingdotseq 270$$

Then next, if, α, β, γ, μ is 35% each (Highest margin), and ti is 15%, and ρ is 10%:

$$F_2 = 100\left(1+\frac{35}{100}\right)\left(1+\frac{35}{100}\right)\left(1+\frac{10}{100}\right)\left(2+\frac{15}{100}\right)\left(1+\frac{35}{100}\right)\left(1+\frac{35}{100}\right)$$

$$=100(1.35)(1.35)(1.05)(1.15)(1.35)(1.35)$$

$$\fallingdotseq 400$$

Namely, about 3 to 4 times of production cost A in an advanced country can be an approximated retail price in the developing country in free commercial basis of imported farm machinery. (In actual cases, sometimes sales tax should be added to price F, and about 10% discount of retail price is sometimes applied to cash buying.)

F. Retail Price Concept of Imported Farm Machine in Developing Country for Retail Price in Advanced Country:

In an advanced country, a design engineer has the concept that about 1.5 to 2 times of factory cost of mass produced farm machinery is the retail price to a farmer. Because, in the domestic market, there are three distribution networks existing.

1. Manufactur—Selling Company of Manufacturer—Main Dealer—Retailer
2. Manufacturer—Sole Agent or Selling Company—Retailer
3. Manufactur—Retailer

Number 1 is the most complicated with four stages. Many manufacturers are making their efforts to save at least one stage in order to offer cheaper machines to retailers. In case of Number 2, the equation of price structure will be

$$G = A\left(1+\frac{\alpha}{100}\right)\left(1+\frac{b}{100}\right)\left(1+\frac{c}{100}\right)$$

Where: G = retail price in the domestic market
b = marginal percentage of second stage, Sole Agent, Etc.
C = marginal percentage of retailer

Then if, α, b or c is about 15% and A is 100

$$G_1 = 100\left(1+\frac{15}{100}\right)\left(1+\frac{15}{100}\right)\left(1+\frac{15}{100}\right)$$

$$=100(1.15)(1.15)(1.15)$$

$$=153$$

and if the marginal percentage is about 25% in order to expect better service,

$$G_2 = 100(1.25)(1.25)(1.25)$$

$$=197$$

Namely, about 1.5 to 2 times of production-factory cost can be the retail price in the domestic market. This means that for example, a design engineer has to have the common idea that about 1.8 times of production price is retail price expected in the market, when he has to have a lay-out design for some new machine. *Also we may say that, about 1.5 to 3 times of the retail price in the original country is the retail price in the importing country.*

It is the usual trend to make the retail price high that the developing country has following marketing character to importing farm machinery:

* possibility to cause many middle agencies and men because of far distribution distance and special many international business
* difficulty to have mass sale because of small economic power of farm area
* necessity to have perfect package of machinery for long distance and time
* necessity to pay freight and insurance expenses, tax and high percentage of bank interests
* possibility to cause bigger

Tablel-5 Market Price of Imported Machines in the Philippines (1969-1971)

Types of Machine	Approximate Retail Price in the Philippines (dollars)	Approximate Retail Price in original Country (dollars)
9 to 12 PS Power Tiller	(3000－3500)	(985－1050)
8 to 11 PS Power Tiller	(2200－2500)	(900－1000)
6 to 9 PS Power Tiller	(1900－2100)	(730－740)
Attachments:		
Iron Lugged Wheel	(80－86)	(36)
Cage Wheel for Puddling	(150)	(56)
Japanese Iron Plow	(135－230)	(30－60)
Rotary Mower	(280－300)	(120)
Trailer	(330)	(56－100)
Riding Tractors:		
1) 20 PS	(5000)	(2600)
2) 30 PS	(7500)	(3000－3500)
3) 40 PS	(10,000)	( )
4) 50 PS	(12,500)	( )

$ 1.00＝￥360＝₱3.90

• Courtesy of many retailers in the Philippines and Japan to the author.

depreciation of service facilities and activities through small sale

Thus, actural retail price of an imported machine will be unexpected high price to farmers, resulting in discouraging for them to purchase.

Table 1-5 is the actual market price of imported machinery in the Philippines in 1969 to 1970, when the author was there as an Unesco Expart in Agricultural Engineering.

G. Bilateral Basis Network

Another method of distribution order that may be cited herein is the Bilateral Basis. Sometimes, this is from government to government direct consignment, or from manufacturer and / or trading agency of producing country to the government of importing country.

By this method, some of the marginal percentages mentioned above will be eliminated and the buying price of farmers will be cheaper.

At any case, post-sales service, maintenance and repairs are very important in the life of farm machinery. They have to be considered as important as the method to import and distribute cheaper machinery, for economy and productive use of the machines.

It could be said that, the best way is to import those farm machinery that the manufacturers had already established service network, and that these manufacturers agreed to have perfect post-sales service to those farm machinery. If there is none of this, then the Manufacturer, Trading company, together with the government of the importing country has to have enough discussions to find ways and means for perfect post-sales service and trouble shooting network for end-users or farmers.

Other important problem is that, the government of an importing country is eager to protect her domestic manufacturers so as to have her own mechanical industrial fields. However, it would be said that, the capacity of domestic manufacturers to speed up its progress in the manufactures of farm machines might be sometimes impeded, if there were a low cost many farm machinery imported.

Water Pumping using Power Tiller

(Part two)

National Economic Concept of Investment to Imported Farm Machinery for Farm Mechanization in Developing Countries (An Example in the Philippines)

by JUN SAKAI

A. Background

When I gave a seminar titled "The Philippines Farming and its Mechanizing Condition" to the university staffs and students in the Philippines in 1970, the expenses necessary to have as enough quantity of farm tractors and other machinery in the country as in advanced countries were estimated. Although this calculation is not of very scientific theory but just practical discussion on the basis of scientific assumption, we found out that the estimated conceptional data must be phylosophical idea to find the direction of farm mechanization and farm machinery industrial field in developing countries for the future.

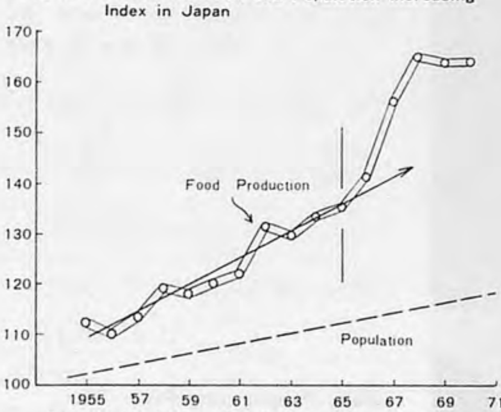
According to the UN's estimation, the world's total population is increasing at the rate of about 2% a year. In 2000 A.D. it will reach 6.1 billion, 3.5 billion of which will be the population of Asia, as you know, approximation to the number of 1970's world population (3.6 billion).

In most advancing countries including the Philippines, the increasing rate of population is about 2 to 3% a year. So that, within few decades, it will reach twice the number of today's population. Also the fact means that they will need at least more than twice the quantity of present food production.

Some of important technological solutions to increase food production are irrigation and drainage, plant breeding and farm mechanization.

Within about 2 decades from 1952 in Japan, food production was increased about 60% as shown in **fig. 2-1**, after being utilized effective technology and knowledge to reconstruct the ruined country and lack of food

Fig. 2-1 Food Production and Population Increasing Index in Japan



Sauce: Monthly Bulletin of Agr. Economics & Statistics (FAO)

Table 2-1 Philippine Total Area of All Farms, Total Area of Rice Farms, and Average Size of Farm Based on Number of Farms in 1960[1]

Year	Total area (all farms) 1000 ha*	Average size (all farms) ha **	Total area (rice farms) 1000 ha*	Average size (rice farms) ha **
1955	6,434.3	2.97	2,655.5	2.55
1956	6,816.7	3.15	2,742.5	2.63
1957	7,003.6	3.23	2,768.1	2.66
1958	6,996.9	3.23	3,154.1	3.03
1959	7,910.0	3.65	3,329.4	3.20
1960	7,595.9	3.51	3,306.5	3.17
1961	7,833.7	3.62	3,197.8	3.07
1962	7,917.8	3.66	3,179.2	3.05
1963	7,934.2	3.66	3,161.3	3.03
1964	7,955.6	3.67	3,087.4	2.96
1965	8,251.7	3.81	3,199.7	3.07
1966	8,296.3	3.83	3,109.2	2.98
1967	8,513.3	3.93	3,096.1	2.97
1968	(8,820.5)	4.07	3,332.0 @	3.20

Sources:
- * Yearbook of Philippine Statistics 1966
  Journal of Philippine Statistics, Vol. 21, No.2, 1970
- ** 2,166.2 thousands number of farms, 1960, from Yearbook of Philippine Statistics 1966, as divisor, of total area of all farms.
  1,041.8 thousands number of rice farmers, 1960, from Yearbook of Philippine statistics 1966, as divisor, of total area of rice farms.
- @ FAO Production Yearbook 1969, Vol. 23
- 1) By Cezar G. Salas, Jun Sakai

after World War II.

Especially, the rapid rising curve after 1965 in **fig. 2-1** means the result of increasing of mainly rice production, and also stepping up of vegetable crops and livestock products. However in that period, the population engaging in farming was decreasing and progress of irrigation or new variety was usual.

But in the field of farm mechanization, there was a fact that the spread of farm mechanization, begun at about 1955, rose so rapidly that the number of hand tractors and power tillers prevailing in farm area became almost saturated in around 1965, so that many timely farm works including deep cultivation with farm machines pervaded in the country. In addition, we think, stepping up of labour productivity of rice production with the machinery became one of important causes to share a part of farm labour to other farm production.

In this way, farm mechanization is effective and important to increase the total quantity of food production within few decades, mutually assisting with effects of plant breading, irrigation and other technologies.

In that case, if farm machinery industrial fields were not in time in developing countries within few decades, they should continue to import necessary farm machines by mainly the trading profit of export of the primary products and others.

This report is a trial estimation of it, and its result suggests the occurrence of nationally and economically important issues.

The Philippines has arable land and land under permanent crops of about 9 million hectares including about 3 million hectares paddy rice fields as shown inn **table 2-1**. The average size of rice farm is about 3 hectares while the average one of all farm is about 4 hectares. Relative **table 2-2** and **2-3** were used to get **table 2-4**.

B. Small Scale Mechanization

Japan has about 6 million hectares of arable land including permanent crops, about 3 million hectares of which is paddy rice fields. Size of one rice farm is about one hectare where about 2 farmers are working. This is almost similar to the Philippine condition, except size of the farm and climate condition etc.

About 3 million power tillers of 2 to 14 horsepower are in Japan, and these small scale mechanization is slightly and slowly chang-

Table 2-2 Philippine Number of All Farms, Total Area, and Average Size of Farm.[1]

Year	Number of All Farms* (1000)	Total Area** (1000 ha)	Average size of Farm (ha)
1955	1,971.1	6,434.3	3.26
1956	1,997.4	6,816.7	3.41
1957	2,013.7	7,003.6	3.48
1958	2,050.1	6,996.9	3.41
1959	2,076.4	7,910.0	3.81
1960	2,102.7 (2,166.2)	7,595.9	3.61 (3.51)
1961	2,129.0	7,833.7	3.68
1962	2,155.3	7,917.8	3.67
1963	2,181.6	7,934.2	3.64
1964	2,207.9	7,955.6	3.60
1965	2,234.3	8,251.7	3.69
1966	2,260.6	8,296.3	3.67
1967	2,286.9	8,513.3	3.72
1968	2,313.2	(8,820.5)	3.81

Sources:
* Basic Data obtained from: Yearbook Philippine Statistics 1966. Calculated by regression. (On the assumption that number of farm increases as population increases, through division of land holdings by families)
** Journal of Philippine Statistics, Vol. 21, No. 2, 1970
( ) Assumption
( ) Actual value for that year, from basic data.
1) By Cezar G. Salas, Jun Sakai

Table 2-3 Philippine Population Distribution from 1955 to 1968[2]

Year	Total Population* (1000)	Agricultural Population[1] (1000)	Working Population (1000)	Agricultural Working Population (1000)
1955	23,568	13,669	7,919a	4,666a
1956	24,288	14,087	8,161a	4,809a
1957	25,030	14,517	8,149*	4,938*
1958	25,795	14,961	8,782*	5,325*
1959	26,584	15,419	8,836*	5,450
1960	27,410	15,898	9,115a	5,533a
1961	28,313	16,422	9,395*	5,617*
1962	29,257	16,969	9,680*	5,910*
**1963	30,241	17,540	10,315	6,131
**1964	31,270	18,449	10,572	6,188
**1965	32,345	18,738	10,543	6,062
**1966	33,477	19,417	11,032	6,275
@1967	34,656	20,100	12,185	6,835
@1968	35,883	20,812	12,481	7,078

Sources:
* Yearbook of Philippine Statistics 1966
FAO Production Yearbook 1969, Vol.23
** Data on Labor Force (Working), obtained from the BCS Survey of Households Bulletin, May 1966, S-No. 20, (1963 to 1966, May surveys).
@ Data on Labor Force (Working), obtained from The BCS Survey of Household Bulletin, May 1968, S-No. 25, (1967 & 1968, May surveys)
1) Except for 1965, which is obtained from FAO Production Yearbook 1969, Vol. 23, all values were calculated on the assumption that during the years 1955 to 1968, agricultural population is on the average of 58% of total population.
a Calculated based on the percentage (average) of obtained data for the group: (1957-1968).
2) By Cezar G. Salas, Jun Sakai

ing to a little bigger one because of social problems.

According to Farm Machinery Statistics shown in **table 2-5,** Japan has 3.2 ps per hectare.

(When we use"horsepower per hectares", we can have two or three relative ratios or calculations.

1. total available ps/ total area of arable land and land under permanent crops
2. total available ps/ total area under cultivation
3. total available ps / total area of cultivated land

In advanced countries, multiple cropping or rotational cropping system and also land in fallow are popular, while developing countries have few application of them. So that, Number 2, that is the ratio of the total available ps to the total area under cultivation, should be used in this study.)

Then the necessary total horsepower needed in the Philippines is:

8,513,300ha. × 3.2ps = 26,600,000ps

Comparing the farming condition of Jpapan with the Philippines' under consideration of climate and soil condition etc., big power tillers of 9 to 14 ps will be adaptable to 3 to 4 hectares--average size of Philippine farming. (5 to 6 ps is the average one of power tillers in Japan.) If so, the necessary number of such power tillers in the Philippines is :

26,600,000ps ÷ 9ps ≒ 3,000,000units to

26,600,000ps ÷ 14ps = 1,900,000units

This means also that about 2.3 million power tillers should be in the Philippines in order to get advanced mechanization of farming like Japan.

When a country has to import the machinery, she has to pay at least FOB price to the producing country. Approximate FOB price of a big power tiller with minimum but basic attachments such as iron wheels, rotary knives, tools, etc. can be estimated about $1000.

Then total foreign currency necessary to import them is:

$1000 × 2,300,000 tractors = $2.3 Billion

Then next, mechanized farming requires many other power machinery. Main ones are transplanter, sprayer, weeder, combined harvester or binder, thresher, dryer, cutter, trailer, etc. The total price of these machines with a power tiller is, as they say, usually 4 to 5 times of power tiller held by a farm in Japan.

Table 2-4 Philippine Number of Persons per Farm Family and Number of Farmers per Farm Calculated From Basic Data Obtained:[1] (1955 to 1968)

Year	Based on Increasing Based on Constant Nos. of all Farms 2,166.2 thousands				Average	
	Persons/ F.Family (A)	Farmers/ Farm (B)	Persons/ F.Family (C)	Farmers/ Farm (D)	Per./ F.Family (A+C)/2	Farmers Farm (B+D)/2
1955	6.9	2.4	6.3	2.2	6.6	2.3
1956	7.0	2.4	6.5	2.2	6.7	2.3
1957	7.2	2.4	6.7	2.3	6.9	2.4
1958	7.3	2.6	6.9	2.5	7.1	2.5
1959	7.4	2.6	7.1	2.5	7.2	2.5
1960	7.5	2.6	7.3	2.6	7.4	2.6
1961	7.7	2.6	7.6	2.6	7.6	2.6
1962	7.8	2.7	7.8	2.7	7.8	2.7
1963	8.0	2.8	8.1	2.8	8.0	2.8
1964	8.3	2.8	8.5	2.8	8.4	2.8
1965	8.4	2.7	8.6	2.8	8.5	2.8
1966	8.6	2.8	9.0	2.9	8.8	2.8
1967	8.8	3.0	9.3	3.2	9.0	3.1
1968	9.0	3.0	9.6	3.3	9.3	3.2

Sources:

(A): Calculated Agricultural Population in Table No.7 divided by the corresponding calculated number of all farms in Table No. 2b.

(B): Agricultural working population in Table No. 7 divided by the corresponding calculated number of all farms in Table No. 2b.

(C): Calculated Agricultural Population in Table No. 7 divided by 2,166,200 farms.

(D): Agricultural working population in Table No. 2b divided by 2,166,200 farms.

Basic Data obtained from:

- FAO Production Yearbook 1969, Vol. 23
- Journal of Philippine Statistics Vol. 21, No. 2, 1970
- The BCS Survey of Household Bulletin May 1966 & May 1968
- Yearbook of Philippine Statistics 1966

1) By Cezar G. Salas, Jun Sakai

Table 2-5 Structure of Selected Countries Similar to the Philippines

	1000 ha AL	1000 P	1000 NT NH	ps/ha HP/AL	ps/ha HP/LUC	ha/farm AF
Phil.	8,546	37,158				3 to4
Japan	5,603	102,321	0.1 3,030	2.8	3.2	1.1
USA	176,440	203,213	4,820 770	0.7	1.7	47.8
UK	7,261	55,534	352.4 73 .0	0.8	2.2	18.5
France	18,903	50,320	1,051.2 231.8	1.3	2.1	8.9
Germany Fed. Rep.	8,174	58,707	1,256.9 100.0	2.1	3.5	4.9
Italy	15,001	53,170	509.2 127.2	1.0	1.3	3.5

*AL: Arable land & land under permanent crops
P : Total population
NT: Total number of riding Tractor on farm
NH: Total number of walking Tractor on farm
HP: Total horsepower of tractor on farm
LUC: Total land area under cultivation
AF: Average size under cultivation / farm

*Sources:
FAO production year book 1970
Farm Machinery Statistic 1971, Farm Machinery Industrial Research Crop. Japan

Also, it is said that the total price of such main machinery is a little bigger than annual income of the farm in Japan. Then,

\$2.3 Billion × 4 to 5 ≒ \$9 to 12 Billion

This shows that the Philippines has to pay about \$9 to 12 Billion to the producing country for import, to have perfect mechanized farming, like Japan. Not only that mentioned above, we know that average life of general farm machinery, depending on statistical data in Japan, is about 5 to 7 years. This means about one-fifth to one-seventh of total machinery has to be renewed. So that, about \$1.3 to 2.4 Billion per year has to be paid out to the producing country in order to keep necessary quantity of power tillers in the Philippines. Moreover, repairing and consumptive parts for maintenance must naturally be imported.

Lately, several knockdown factories of farm machinery are being established in the Philippines. If 50% of total cost of production is requested to be locally made, and this can be progressed, necessary payment to import the parts can be a little less than half of expense calculated above as a rule.

C. Big Scale Mechanization

Big scale mechanization can be done with 4-wheel riding tractors and other big machinery. As a rule, big scale farm machinery is better to be used on wide fields than on narrow fields, while the small scale farm mechanization lead by the power tillers is easier to be applied on the traditional small fields.

In the continental country, there are many of wide enough and flat fields where the big riding tractors and machinery can be used efficiently. However, in island countries, many farming areas are covered by traditional small size paddy fileds that are surrounded by the levees and the height of each field-level is delicately different. In such farming area, an excellent expert from advanced countries is apt to advice to have engineering construction project, of remaking traditional rice field group to flat and wide one.

Bigger scale mechanization will require more reformations of traditional small fields. In Japan, reformation of field structure, in order to apply higher efficient farm mechanization of bigger machines is being performed. They say that the investment for it is about \$1500 to 2000 per hectare.

Then, if the Philippines is covered by American type mechanization, the necessary total power will be about 14.4 million horsepower, by means of 1.7 ps/ha in **table 2-5**, and 8.5 million hectares in **table 2-1**. As the average horsepower of a tractor in the United States is gradually increasing from 60 to 65 horsepower.

If 60 ps riding tractors are applied in the Philippines, total necessary units is:

14,500,000ps ÷ 60ps ≒ 242,000 tractors

The retail price of a 60 ps riding tractor imported into the Philippines is about \$15,000. Basic attachments to till are plows or rotary tillers, wheels, tools and so forth. Such additional expenses can be estimated about \$2500. Then, FOB price of one set can be guessed around \$8000. If so, the foreign currency necessary to pay for importing them should be;

242,000 tractors × \$8000 ≒ \$2 Billion

This expense is a little smaller but almost similar in amount to that of small scale mechanization. They say that primary investment of big scale mechanization is bigger than small scale one, but big scale mechanization has higher productivity than small scale one. The opinion has to be added more as following:

If big scale machinery is utilized as efficiently as in the United States, primary investment for big scale farm mechanization can be similar or a little smaller than that of small scale one. However, in order to have high efficient utilization of the big machine, if special investment for reformation of traditional field structure is necessary, first investment will become much higher than that of small scale mechanization.

Total investment to import necessary main big machinery group, can be guessed about the same concept with that of small scale one. But the author wish to reserve to estimate, because of no accurate data on hand about FOB price of American big scale machinery.

Lately, the Philippines has also a knockdown factory of riding tractors. Necessary expenses can be decreased depending on production % of locally made parts.

D. Medium Scale Mechanization

Investigating countries similar to the Philippines in size and farming conditions, among advanced countries in Europe, we can find England, France, West Germany, Italy, etc. in population, and West Germany, England, etc. in size of arable land. These countries have so different problems in farms that the government and people are making efforts to reform their farming structure as one of important national problems.

Omitting England, who has big scale farm mechanization of U.S. type, average arable land per farm in West Germany and Italy is about 3.5 to 5 hectares. That of France is about 9 hectares. (Refer to **table 2-5**) These are said medium scale farm mechanization in the world.

As shown in **table 2-1**, they have 0.5 to 1.3 million tractors. If the Philippines wish to get the same level of farm mechanization as those European countries', today's total holdings of their tractors will be her goal number. Average horsepower of tractors of medium scale is considered about 20 to 40 ps.

Then, approximate price of FOB can be guessed about $3000 per a tractor and $2000 per its basic attachments. Total investment to import all tractors is

$5000 × 500,000 to 1,300,000 units = $2.5 to 6.5 Billion

E. Relation between Such Amount of Investment and the National Economy——Conclusion

Many conceptional prices of investments were calculated as following:

In any case of mechanization, the Philippines is supposed to have to prepare $2 to 7 Billion just to import only tractors and basic attachments for tillage.

More than $10 to 20 Billion for importing main farm Machinery has to be spent. Moreover, maintenance and repairing expenses should be paid to import the parts.

Then, the national economic situation of the Philippines is as follows.

The total amount of dollar in the world in 1971 was only about $110 Billion. For these ten years, the Philippines had only about $7 to 72 million of foreign exchange reserve, and about $44 to 160 million of international reserve. Total of them was about $100 to 200 million only as shown in **table 2-6.** When total holding of them became less than $100 million, she had to have a national economic panic of Peso devaluation, which happened in 1970. (₱3.8 per dollar became ₱5 to ₱6 in floating rate per dollar.)

Her scale of annual trade is about $2 Billion as shown in **table 2-7.** Although the government is doing their best to increase the export of primary products and others, and to prevent from importing too many things through high import duties and so on, the balance of her trade shows a loss every year. These phenomena are seen in most of other developing countries too.

The sum of car import including parts is second, next to general machines, in importing items. As the result, it often becomes national and financial problems. This expense of FOB is about $100 million annually. This means, even if she imports farm machinery like cars, it will take more than 100 years to have enough amount of farm machinery like advanced countries. In other words, the money more than the sum of her annual total import, more than ten times of today's car import expense, can support only to keep total holding of farm machinery necessary to have well mechanized farming in the country.

Generally speaking, economic, social, geographical, climate and farming conditions etc. in developing countries are not the same but similar among them.

We can say that developing countries may import farm machinery to get good experiences enough to use and test those adaptability to the domestic condition.

Table 2-6 International Reserve of the Central Bank and Foreign Exchange of Commercial Banks: (Philippines, 1958 to 1965)

(In million U.S. dollars)

Reserve & Exchange Holdings	1958	1959	1960	1961	1962	1963	1964	1965 1)
Total	145.3	162.9	192.1	103.3	140.8	147.5	134.4	166.8
International reserve of CB	91.6	89.9	120.0	44.1	75.0	109.4	123.3	159.9
Foreign exchange holdings of commercial banks:								
Net	53.7	72.9	72.0	59.3	65.8	38.0	11.1	6.89
Gross	59.5	81.1	76.0	63.7	76.3	88.3	86.3	94.5
Liabilities	5.8	8.2	4.0	4.4	10.5	50.3	75.2	87.6

1) as of September:

Source: Yearbook of Philippine Statistics, 1966

Table 2-7 Trade of the Philippines

(In U.S. Million dollars)

	1963	1964	1965	1966	1967	1968
Export	727	771	794	861	892	848
Import	636	802	835	874	1062	1150
Trade Balance	+81	−31	−41	−13	−180	−302
Car				66	80	92

Sources:
1. FAO Trade Yearbook, 1969, Vol. 23
2. Yearbook of International Trade Statistics, UN New York

Knock down factories should be also imported in order that they may receive any kinds of technical and marketing convenience and know how to produce machines.

Manufacturers in advanced countries have to begin special design and development of new farm machinery suitable to their knock down factory conditions and farming structures.

But, developing countries must not be satisfied with only this. Next stage is to know how to develop new machines of better adaptability and of many variety. To realize it, many ways are considered to be.

If those ways were not put in practice, I am afraid that human technology of agricultural machinery and mechanization of advanced countries would not be utilized effectively to settle a human crisis of food production to occur in the near future. ■■

Establishment of the Internat. Agricultural Mechanization Institute in Asia

<Agricultural Technical Center of National Federation of Agricultural Co-Operative Associations>

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Introduction

In Japan such public opinion is arising that we must assist especially developing countries in agricultural development based on the new plan which is different from former one. And it is a problem that "International Agricultural Mechanization Institute" is probably needed.

Since rice cropping is very popular in Southeast Asia, the institute should lay emphasis on rice cropping. Needless to say, if it can be expanded, it must take up production to processing of every agricultural product as research theme. In that case, however, a huge investment is required. But when we restrict that institute within rice and several main crops, it won't be so much I think.

If establishment fund is offered by Japan or another countries, can't operation fund be offered by each country as membership duty, and can't economically advanced countries in the world offer a part of these funds cooperatively? Even if we concentrate institute's activities to certain crops at present time, this institute will play an important role to promote agricultural mechanization. Consequently I believe it is advisable to establish it as considerably comprehensive research institute, namely rather mechanization research institute than machinery development institute, which will hold economists, biologists and mechanical engineers. This institute will also train technicians who can service popularized agricultural machinery and manufacture simple hoe, sickle and attachments. They manufacture not only simple implements and machinery but also get repairing technique on advanced agricultural machinery. Generally speaking, repairing of agricultural machinery is not successful unless parts are sufficiently supplied. Such case happens often in developing countries.

Even if machinery are well utilized in fields, considerable loss is caused during processing, storage and transportation. Problems after harvesting should be one of main themes.

Since there are the definite dry-season and rainy-season in some areas of Southeast Asia, they can't use the land efficiently without mechanization. Development of agricultural machinery, whether they are used by the individual or group, doesn't bear fruits without developing industry--production & marketing, communication and education. As traditions, natural conditions, and crops are various in Southeast Asia, we can't establish the institute which covers all things of every country. We must restrict its object.

Since agricultural organization and administrative organ is defferent in every country, the method of mechanization may well be fairly different.

Therefore every expert of Asia should be concerned with the institute.

Fund Raising

Ten million dollars to fifteen million dollars will be needed as the first fund. The Government of Japan had better offer 1/3 or 2/3 for it. The other will rely on Asian countries and subsidy from other advanced countries in the world.

Operational Fund

As to operational fund, seven million to eight million dollars, Japan should be responsible for 1/2 to 1/3. The 1/3 from participated nations, and moreover membership duties from special agricultural machinery manufacturers and co-operative funds by advanced countries are expected.

Structure of Organization (see fig.)

As to general management of this institute, I hope that each nation appoints directors and that among whom a chief director should be elected.

In respect to management of research activities, the head of institute must be chosen from agricultural engineers with wide experience, separately from a chief director. The reason is that swift settlement and decision making on technical problems are needed for research activity on agricultural machinery and for this purpose an expert with engineering background is suitable. Regarding accounts and rules it is advisable for a chief director to manage cooperating with directors.

Function of Research Division

Agricultural machinery development and research division make researches on engines, tractors, all kinds of farm working machinery, storage, processing and marketing.

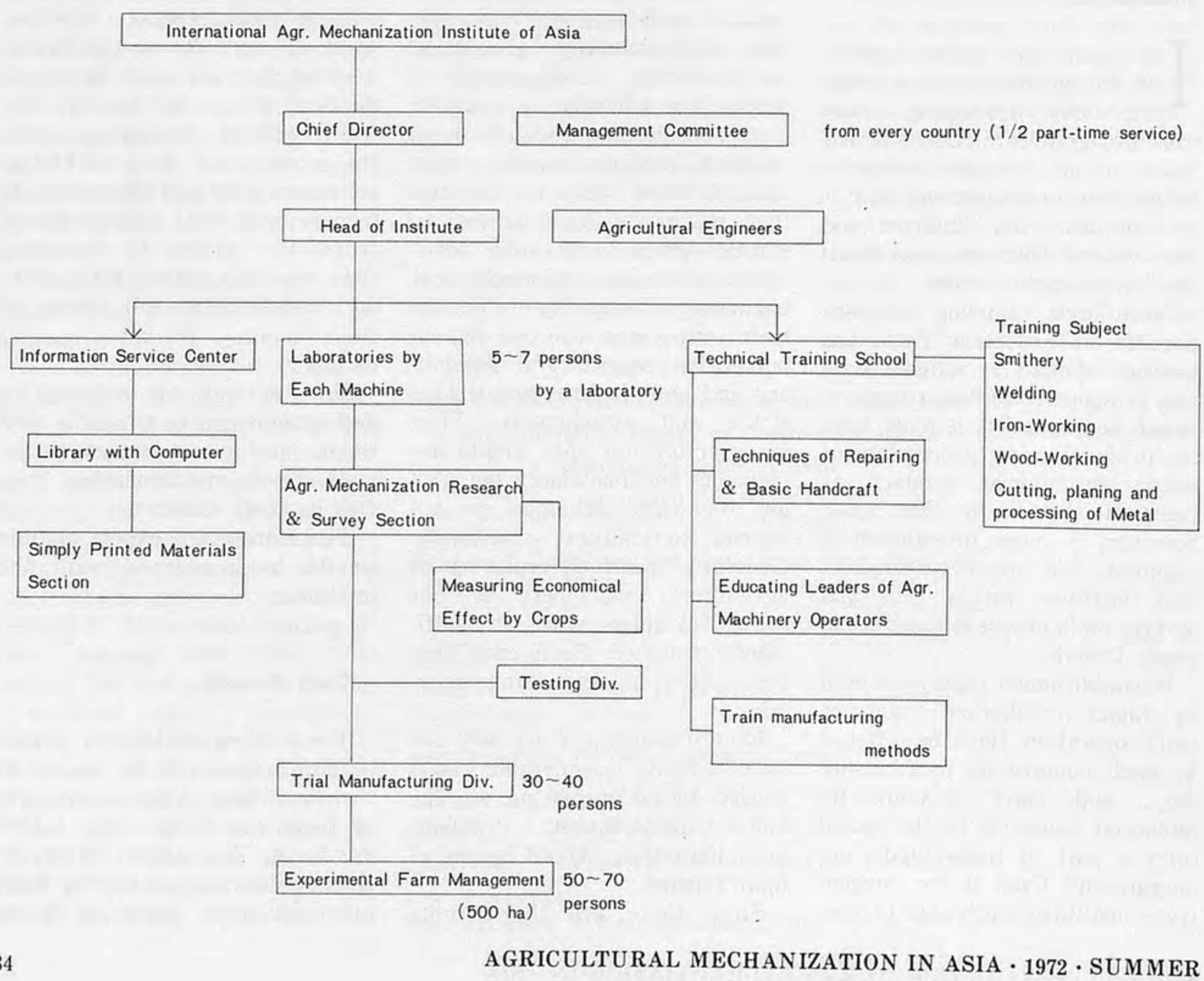
Information Service Center

This center collects various information needed for research from all over the world and offers it to membership countries. Management of a library must be computerized for speedy output.

Training School for Operators, Service Technicians and Manufacturers.

Technical training of repairing of big-sized machinery is put in practice. For this purpose basic techniques of simple smithery, welding, iron-workihg, wood-

〔ORGANIZATION〕



working, metal cutting and processing etc. must be taught attendantly. Trainees are to master skill for manufacturing such simple implements as hand tools and various kind of attachments. Also they get consulting service on how to produce new machinery which will be developed in this institute. Additionally education of operators of agricultural machinery is also done there.

Completion of Trial Manufacturing Section

Trial Manufacturing Section is generally neglected. The institute should have considerable ability of trial manufacturing itself, I think. So it is needful to make mechanical preparations and complete equipments for trial manufacturing. A complete production model is needed for extension to industrial people. In that case a committee evaluates repeatedly improved machinery of trial-making and offers them and their drawings to each country.

Attached Farm

Even if development of agricultural machinery is successful, sufficient test is needed before actual manufacture at works. In that farm, engineers can do every kind of tests at any time. Complete system for irrigation and drainage is needed.

Facilities

Facilities needed are as follows : attached farms, research facilities and lodgings, administration building, laboratories, workshop, survey and information room, library, students lodgings, lecture rooms and machinery shed. Electric service and drain system are especially needful. Naturally an air-conditioning installation should be instituted in every building. Testing rooms are needed for all kinds of experiment.

Agricultural Mechanization Research & Survey Section

Survey section is required for evaluation of agricultural mechanization in addition to the divisions of development and research on them as stated above. Though the situation is different in every country, the method to evaluate machinery has not been settled yet, I think.

The aim of the institute is to improve working condition of agriculture firstly and agricultural management by expanding land use secondly. This must become the driving force in agricultural countries.

Now the national economies differ in countries. We should forecast how agricultural mechanization will influence national economies from wider viewpoints. I hope research divisions in the institute continue abovementioned research to establish such a system. This division will also do various market research on their new machinery.

Conclusion

(1) Japan offers more than half of fund.

(2) In respect of personnel, nations concerned send directors. A chief director is chosen by election.

(3) Engineers recommended by each country promote joint research.

(4) Complete information section does information service. It utilizes computerized system.

(5) Management fund is burdened by Japan and other countries. But Japan should undertake more than half of it.

(6) This institute trains operators, engineers, technicians and manufacturers. Each country is distressed with this point in promoting agricultural mechanization.

(7) To evaluate agricultural mechanization is very important. It is necessary to evaluate total economic effect by agricultural mechanization. As a matter of fact it has not been evaluated exactly also in Japan.

Agricultural machinery liberates farmers from heavy works and gives them rest and time to think and get knowledge about introduction of techniques. We must think of better plan on production, processing, storage and supply to consumers to improve conditions of agricultural economy. We must research on prevention of economical loss which occurs after production of agricultural products.

How should we put rich sun energy of the south countries to practical use with development and use of agricultural machinery. The agricultural pattern will surely change by that. Research on revolutional agriculture in the tropical and subtropical zones such as multi-cropping method and its mechanization should be largely promoted. Consequently we need co-operation by all kinds of people.

Agronomists, mechanical engineers, economists etc. should be included.

(8) As stated above what this institute aims at is fairy different from what had been planned up to this time. Since mere partial research is apt to fade away unless we think about the total system of agricultural mechanization, this institute should be a complete one. This institute will cover every phase of agricultural mechanization to be able to stimulate and lead every field such as governmental planning people, agronomist, economist, production people, dealers, educational people, financial people, and so on.

Each institute in every country

(Continued on page 40)

A Proposal for the Establishment of the Asian Agricultural Machinery Institute

by
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I. Background

A. Agriculture and mechanization in Asia

1. Although lately there have been increases in food production in many Asian countries, agricultural mechanization still lags because insufficient inducements have been given for the manufacture of suitable modern agricultural machinery in the developing countries. Facilities to support farm mechanization, such as feeder roads and farm credits in the rural areas, have not yet been substantially expanded.

2. In the Asian developing countries the ownership of agricultural machinery of imported designs and models has been confined to a small fraction of farmers and plantation enterprises engaged in agricultural production on a commercial scale. For the greater mass of farmers in the Asian region who are subsisting upon the produce of small tracts of land, ownership of agricultural machinery may have to await the time when their farm incomes have increased to a level that will justify the purchases of low-cost agricultural machinery suited to their particular needs.

3. Heavy demands for agricultural machinery, particularly tractors, power tillers, plant protection equipments, harvesters and grain processing machinery, are expected in the near future. Such types of agricultural machinery are now imported; hence they are expensive and require foreign exchange; moreover, their usefulness may be limited as they are not always suited to the type of terrain, or the climatic and agronomic conditions prevailing in the Asian countries. At the same time, there has been wrong application of the machinery. This has been caused at times by ignorance of both the agricultural machinery supplier and the farmers.

4. That the specifications for such equipment should conform to the economic limitations governing upon Asian farms and to the above-mentioned factors is a matter which merits the attention of many governments in this region. A pooling of the region's resources would ensure optimum machinery design and, with proper promotion, provide justification of the manufacture of such machinery at competitive prices. There is also a need to improve the designs of hand animal-powered tools and equipment which, hitherto, have not benefited from modern agricultural technology.

B. Trends in manufacture of agricultural machinery

5. The manufacture of agricultural machinery in the region has not developed satisfactorily owing to such limitations as lack of investment capital, technology and trained manpower. To encourage the growth of this industry, some Asian countries have provided inducements attracting investments to this filed. Lately, leading agricultural machinery producers have been collaborating with domestic manufacturers in supplying some modern types of agricultural machinery. However, there is still great need to developed suitable types and sizes of agricultural machinery suitable for small Asian farms with low farmer incomes.

II. Circumstances of the proposed institute

6. The establishment of a re-

gional agency for agricultural machinery was recommended by the ECAFE/UNIDO Fact-Finding Team on Industries manufacturing Agricultural Machinery which visited twelve countries in the ECAFE region in 1968-69. This recommendation was supported by the Asian Industrial Development Council (AIDC) during its fourth and fifth sessions and by the Second Asian Conference on Industrialization held in Tokyo in 1970. The Expert Team on Tractors & Power Tillers organized by ECAFE in 1971 recommended that a regional institute would be more appropriate.

7. The AIDC at its seventh session in 1972 carefully considered the establishment of a regional institute for agricultural machinery, and decided that an expert working group consisting of representatives of interested member countries in the ECAFE region and of organizations such as FAO, IBRD, UNDP, UNIDO, ILO, ADB and IRRI be convened to study the matter further.

8. The AIDC requested the ECAFE secretariat to call this expert working group as soon as possible so that its findings could be made known to member countries and a decision taken at the eighth session of the AIDC in 1973. The 28th session of the Commission in 1972 endorsed the need for a study of the various aspects of the setting-up of a regional institute.

9. According to an information, the necessity for the establishment of an international institute for agricultural machinery was proposed by the participants at the Asian Symposium on Farm Mechanization held in Tokyo 1970, which was organized by the Tropical Agriculture Research Centre Japan; and at the International Seminar on the Mechanization of Rice Production and Processing held in Paramaribo, Surinam 1971 sponsored by FAO and UNIDO. The other hand UNIDO is also interested in such project.

10. It was felt that such an institute could undertake projects to improve on the multitude of designs and sizes of agricultural machinery available in the region. This Institute, if given appropriate national and international support, would be able to provide integrated approach to the overall problems of both farm mechanization and development of industries manufacturing agricultural machinery in Asia.

III. Justification for a regional institute

11. As mentioned earlier, the types of agricultural machinery presently available in the region are mainly imported and often not precisely applicable for use in the prevailing Asian conditions. In developed countries, research and development of new machines is primarily done by the manufacturers. But in developing countries, the manufacturers do not have the resources for this. It is therefore considered necessary to organize a directed effort in the development and selection of machinery designs within the economic limitations and considering the climatic, soil and other agronomic factors prevailing at Asian farms. At the same time, the machinery has to be manufactured indigenously utilizing the limited availability of construction materials as well as metalworking processes. This effort could be better organized in a cooperative manner on a regional scale at an appropriate institute, thus minimizing the duplication of effort and facilitating the exchange of experiences.

12. The establishment of such an institute would assist the functioning of national institutes in this field where they exist. Its resources would be utilized to supplement the work of the national institute and of local manufacturers requesting assistance in design development, machinery testing, prototype manufacture and performances evaluation studies. It would undertake development work which would not generally be done elsewhere. It would permit the inter-change of ideas between countries under an appropriate aegis, which may not be easy otherwise.

13. The regional institute would make available the services of leading international experts in the field and would pool resources with other related bodies, including national institutes within and outside the region. The institute would be entrusted with projects to rationalize and improve on the multitude of designs and sizes of agricultural machinery available in Asia. It would provide strong impetus for leading manufacturers to focus their attention on the precise needs of the region. For instance, adoption of some measure of regional standardization of certain types of agricultural machinery would provide inducement for manufacturers to produce equipment at higher output levels, thus deriving the benefits of low cost production. This could also lead to a rational divivsion of the manufacture of equipment and equipment components within the countries of the region.

14. Arising from the proposed activities of the regional institute, it is expected that the utilization and manufacturing of agricultural machinery would be expanded, thus in the long run increasing the level of agricultural productivity and food production in Asian countries.

15. It admits of no further discussion from the global point of view, that such a regional institute for practical development research, should be established in each region such as Africa, Asia, Middle & Near East and Latin America, where prevailing are difficult conditions respectively.

In addition to the regional institutes, a central institute for comprehensive and fundamental research on agricultural machinery would be necessary to establishment in the future.

IV. Scope of activities of the institute

16. The proposed institute will engage in the assimilation of technology, its transfer and adaptation to the distinctive requirements of Asian farming. Its efforts will be in two directions—development and improvement on agricultural machinery and applied research for adaptation of available equipment. The object would be to evolve machinery designs which are not only suitable for use on Asian farms but which are also low in cost, simple in operation, more durable and capable of indigenous manufacture.

17. The institute may be called as the *Asian Agricultural Machinery Institute.* It is expected that co-operation and substantive support will be received from ECAFE member and supporting countries, international organizations, private foundations, leading machinery producers and their associations.

18. In formulating its programme of work the institute should keep in view the following considerations:

(i) The activity undertaken should fill a gap in the efforts of national institutions and of manufacturers in member countries;

(ii) The activity should normally be such as can more advantageously be undertaken at the regional level;

(iii) Its programmes of technical co-operation in the fields of agricultural mechanization and machinery manufacturing should be of clear benefit to member countries;

(iv) The activity may, where feasible, be undertaken through or with the help of national and international institutions, professional or academic bodies, universities, manufacturers and their associations, and specialized agencies of the United Nations.

19. The substantive functions of the institute in the fields of both agricultural mechanization and industries manufacturing agricultural machinery would be broadly as follows:

(i) Development and improvement on suitable machinery designs, manufacture of prototypes.

(ii) Research and comparative studies for adaptation.

(iii) Information collection, development, and dissemination.

(iv) Advisory and consultancy services.

(v) Training services.

(vi) Other related problems on agricultural machinery.

(vii) Co-operation with other organizations.

These are interrelated and mutually supportive functions, and will have to be tackled with an inter-disciplinary approach.

V. Organizational framework

A. Facilities and site

20. The facilities required for the proposed institute include buildings and furniture for the offices of the research and administrative staff, library and publications, design and engineering workshops, dormitories and conference rooms. In addition, machine tools, forging and casting machinery, testing equipment, prototype manufacturing facilities and repair and maintenance equipment are required. Suitable agricultural land should be available for use in experiments, particularly in studies of the performance of new and improved designs of agricultural machinery on wet and dry land.

21. Subject to the agreement of member countries, the proposed institute will be established on a site to be developed and leased or donated by the host country.

Plowing after rice harvest using power

The land required should be situated within easy reach of an urban area where communications, road and air transport connexions, engineering and supporting shops, and business and commercial districts, are available. The host country would be expected to provide the usual privileges and exemptions to international staff.

B. Duration of project

22. The institute should be conceived of as a continuing project. Budget provision should be made to set-up and maintain the institute for three years in the first instance, with the financial support of the participating countries, international organizations and other sources.

23. The need for continuity of the institute suggests that there should be a review of its constitution and work programme after it has passed through its formative stage. The review would be necessary not only to consider improvement and assessment of programmes and activities but also to decide on the future set up of the institute as a self sustaining entity.

C. Membership

24. Regular membership to the proposed institute would be opened to all interested developing Asian countries. Similar membership may be extended to interested developed countries within and

tiller (Korea)

outside the region and to participating international organizations. Associate membership would be extended to private industrial organizations and associations in the field.

D. Organization

25. The proposed institute will be headed by a chairman of the Board of Directors and an internationally-recruited Project Director on a fixed-term appointment reporting to a Board of Directors duly appointed as representatives of the members. The Board of Directors would be convened regularly to review and discuss policy matters relating to the work programme of the proposed institute, major projects to be undertaken and the co-ordination of past activities and future. The project director will be assisted by deputy directors, if necessary, and section chiefs composed of high-level specialists such as agricultural economists, agronomists, design and testing engineers for agricultural machinery, and production engineers.

E. Sections

26. As the first stage, a tentative organization of the institute would consist of four sections, research & development laboratories and an experimental farm and workshops. Those sections and laboratories would be reorganized and expanded in the second stage in future.

(i) General Services Section

The section would conduct the general administration of the institute such as personnel affairs, finance, liaison with local government, travel, and other related general services.

(ii) Training Section

The section would promote training on machinery design and agricultural mechanization, specialized training for mechanics, and training for trainers.

(iii) Information & Regional Co-operation Section

The section would organize the exchange of technical, statistical and other related information. It woud also engage in activities such as providing advisory services on request, holding seminars, demonstrations, and promoting regional projects.

(iv) Mechanization Research Section

The section would undertake performance evaluation, systems analysis, field surveys, and research on socio-economic effects of mechanization and farm economics.

(v) Research & Development Laboratories

The section would conduct research on improvement of existing machinery, development of new machinery, and other related problems. Initially, the section would have four laboratories as follows. Later, as the institute develops, these could be subdivided into additional specialized units.

(a) Prime mover & tillage machinery laboratory—for development of tractors and engines for agricultural machinery, tillage machinery such as plows, harrows, ridgers, inter tillage equipment, puddlers, levelers, and other tilling and soil preparation attachments for tractors & power tillers.

(b) Farm operating & harvesting machinery laboratory—for development of cultivation maintenance machinery such as seeders and planters, weeders, sprayer & dusters, fertilizer distributors, pump & irrigation equipment etc. as well as for development of harvesting machinery such as reapers (including hay machinery, combines, binders) and other types for vegetables, fruits and industrial crops.

(c) Processing & storing laboratory—for development of processing machinery such as graders, dryers, processing machinery for rice, wheat and other grains, processing machinery for industrial crops, vegetables & fruits.

Furthermore, the laboratory would conduct research on storage and transportation, such as methods and equipment for packaging, storing, and handling.

(d) Hand tools and animal-drawn equipment laboratory—for development of hand tools and animal drawn equipment, which are important factors in the region.

(vi) Experimental Farm

The section would conduct running tests on the machinery developed, water-proof and endurance tests, field operational tests, comparison tests, and other tests at various sections and/or outside the institute on request. The farm would also be used for training purposes.

(vii) Workshops

The section would organize the production of developed or improved prototype machinery, manufacture of selected components, improvement of prototypes, maintenance of machinery and storages for parts & raw materials.

F. Suggested financial plan

27. The initial investment is expected to be raised from contributions, in **cash or kind,** from member countries, interested concerns in industry, international organizations, private foundations and other supporting bodies. For instance, aside from providing land, the host country might also provide adequate develop-

Modern rice processing plant (India)

ment of the site such as land clearing and levelling, construction of main and feeder roads within the institute and access roads to the urban areas, ground water and electricity, and preferably, a developed farm within or near by the site that would be used as experimental plots. The costs for buildings including furniture and operational equipment may also be contributed by host country and member countries and interested organizations. Agricultural machinery of selected designs and sizes may be contributed by leading agricultural machinery producers and related associations.

2. Member countries, international organizations, and private industry are expected to provide the services of some experts free of cost to the institute. The annual operating expenses are expected to be raised from additional contributions in cash and kind until the institute would be able to be self-sufficient in operational funds derived collectively from membership fees and other sources.

VI. Conclusions

29. If the proposal for the institute is accepted, a high level investigating team composed of experts in the field, to visit countries interested in Asian and discuss with authorities concerned in government and industry the following aspects:

(i) General considerations on the institute's terms of reference and range of activities in relation to the individual needs of the participating countries, including the formulation of an initial work programme of activities for the institute.

(ii) Organizational features and the relationship of the proposed institute to existing national bodies.

(iii) The ranges of membership and the appropriate membership dues and assessments.

(iv) Budgetary considerations including indicative estimates of contributions from member countries, the nature and amounts of incomes to be derived by the institute from activities, and the capability of the institute to be self-sufficient in funds in the long-run.

(v) Possibilities of utilizing existing equipment and facilities from the member countries and the acquisition of additional equipment and related facilities from other countries.

(vi) The nature working relations desired between member countries and the manner of co-ordination to be employed, the need for identifying or establishing new national administrative and co-ordinating machineries in the member countries that will act as liaison and executive counter-parts of the participating countries to the proposed institute.

(The views expressed in this paper are those of author and do not necessarily reflect those of the ECAFE secretariat)

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(Continued from page 35)

co-operates with this institute. For this purpose, research staffs can't stay at the above-mentioned institute for a long time. They must be rapidly relieved one another after they completed their objects in certain period of time. Such persons have to promote their research still more after returning to their countries for the people.

I make it the first understanding matters that we need rather better technique and fund to establish this institute for developing countries, than economically advanced countries.

Postscript

The above-stated idea is so rough. I expect that every country makes efforts to realize this idea earnestly and that experts in this field will repeat discussion so that Japan may offer fund willingly for this project. ■ ■

Implement for Moisture Conservation in Unirrigated Areas

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Development and use of implements suitable for moisture conservation are essential for the success of agriculture under rainfed conditions. About 75 per cent of the total cultivated area in India depends mainly on rains for successful cropping. Such unirrigated areas may be grouped into three categories:

(a) arid and semi-arid areas in regions having potential capability for irrigation facilities but without assured source of water supply at present, (b) humid and sub-humid regions receiving plenty of rains during monsoon but with drought conditions prevailing during the rest of the year, and (c) low rainfall regions suffering from chronic moisture deficiency. India, being a monsonic country, the maximum rainfall generally comes during its monsoon season preceded by a dry summer and followed by a comparatively drier winter. Rainfed agriculture or dry farming is important especially for states like Madhya Pradesh, Maharashtra, Rajasthan, Haryana, Andhra Pradesh, Mysore and Tamil Nadu. Vast areas of cultivated lands in these and other States will be benefited by improved farming practices suitable for unirrigated areas. One of the principal objectives of the cultural practices in unirrigated areas is to conserve and utilize a large portion of the available rainfall for crop production.

Success in dry land farming is dependent on many factors. A most important one is efficient and timely tillage. The major objectives of tillage in unirrigated areas are (a) to conserve moisture, (b) to produce a suitable seedbed (c) to place seed in an environment conducive to germination of seed and growth of the seedling, and (d) to destroy weeds. Implement requirements vary for monsoon and winter crops in unirrigated areas. While deep tillage with soil inverting ploughs and occasional use of subsoilers may be beneficial for conserving the maximum amount of rainfall in the monsoon season, surface tillage equipment which cut beneath the soil surface without turning the tilled layer is desirable for tillage operations for the winter crop.

Deep Tillage

Deep tillage and subsoiling are usually beneficial in conserving moisture in the monsoon season. The general objectives of deep tillage are (1) to deepen the effective plough zone and depths and (2) to break through and shatter plough soles and layers compacted by excessive implement traffic, impermeable soil horizons or other barriers to the movement of moisture and roots through the soil profile.

In many of the unirrigated areas in India repeated ploughing with the deshi plough (traditional wooden plough) has resulted in hard compacted layers below the plough depth, thereby restricting infiltration and movement of water and penetration of roots. The soil layer available for holding moisture and for root penetration are often limited to the plough layer of 10 to 15 centimeters. It has been found that in soils having a compacted plough pan, stratified soils, and soils having relatively thin compacted or cemented layers, subsoiling has substantially improved water and root penetration.

Studies on the effects of the depth of ploughing have revealed that deep ploughing to depths of 15 to 20 centimetres is beneficial in unirrigated areas in the monsoon season. Comparative studies on the effect of tillage with mould board ploughs, deshi ploughs and disc harrows have shown that mould board plough is superior to deshi plough and disc harrow in obtaining favourable soil physical conditions in unirrigated areas. Deep ploughing with mould board ploughs, combined with occasional subsoiling, wherever necessary, is an accepted method of moisture conservation in unirrigated areas.

Deep ploughing has resulted in better yields in many unirrigated areas. The higher yields may be attributed to the better root growth, which is a consequence of the more favourable soil-water relationship in the subsurface layer. The root could absorb more moisture and plant nutrients from a greater soil volume.

Mould board ploughs and disc ploughs are effective in disturbing a relatively deep soil layer and in covering and incorporating crop residues. To prepare the seed bed, for the monsoon crop ploughing with a mould board plough may be followed by two or three operations with a cultivator or disc harrow and land smoothening with a wooden float or plank.

〈Equipment for Subsoiling〉

Subsoilers and chisel ploughs are suitable to break through and shatter compacted or otherwise impermeable soil layers. Hard layers 25 to 35 cm deep may be broken by a chisel plough. The subsoiler is suitable to operate as deep as 60 to 70 cm.

Chisel ploughs have a series of rigidly mounted standards spaced 30 to 45 cm apart and equipped with replaceable teeth or shovels, similar to the arrangement of a field cultivator. The reversible shovel commonly used with heavy duty cultivators is suitable to be used with a chisel plough. The standards are mounted on a strong rigid frame with clamps. The spacing between the standards may be adjusted to suit the type of soil. The number of standards on a frame may be varied to suit the size of the tractor. The frame is so designed that the implement may be hitched to an ordinary wheel tractor equipped with three point hitch and hydraulic control.

Subsoilers have one or more heavy standards with a heavy shoe type bottom to which the cutting blade is fixed. High grade high carbon steel or alloy steel is used in making the cutting blade. The standard and the shoe are made of high carbon steel. The cutting blade is so fixed that it will enter the soil at an angle of about 40° to reduce the draft requirement. It is generally found that the soil is weak in shear. The angle of the weakest plane is close to 45° and it varies between 35° and 45°. The same frame whch is used to fix the chisel plough tines is suitable to fix the subsoiler standard with the help of a suitable clamp.

Subsoilers and pan busters are essentially tractor-drawn implements. They may be operated with an ordinary medium duty tractor. With a tractor of the 25 to 35 h.p. range three chisel bottoms or one subsoiler bottom may be a suitable load. The depth of operation of the implements may be adjusted with the hydraulic control system of the tractor. Under hard soil conditions the desired depth may be obtained by progressively increasing the depth in repeated operations.

Subsoiling is a desirable tillage practice in areas having hard or compacted layers below the plough depth. The most effective results with subsoilers and chisel ploughs are obtained when soil

Subsoiler Used to Break Open Deep Impermeable Soil Layer

A Tractor-Mounted 3-Row Chisel Plough in Operation conditions are dry, thus contributing to the shattering action of the subsoiling operation.

Surface Cultivation and Mulch Tillage Equipment

Subsurface tillage implements are used to till beneath the surface without turning the tilled layer. The tillage operation consists of operation parallel with the land surface to cut weed roots and loosen the soil without major soil disturbance. Besides being effective in killing weeds and leaving a good part of the crop residue on the surface, subsurface tillage implements are required to perform the initial tillage and prepare a satisfactory seedbed with a minimum of surface pulverization. Surface tillage implements consist of V-shaped sweeps, or straight or curved blades, mounted on suitable frames.

〈Sweep Cultivators〉

V-shaped sweeps may be mounted on an ordinary cultivate or frame and can be operated by bullocks or tractors. The reversible shovels attached to cultivator standards may be replaced with V-sweeps to suit conservation farming in unirrigated areas. For operation with animals, the size of sweeps usually ranges from 20 to 30 cm. For subsurface tillage with tractors sweep sizes of 40 to 60 cm or more are recommended.

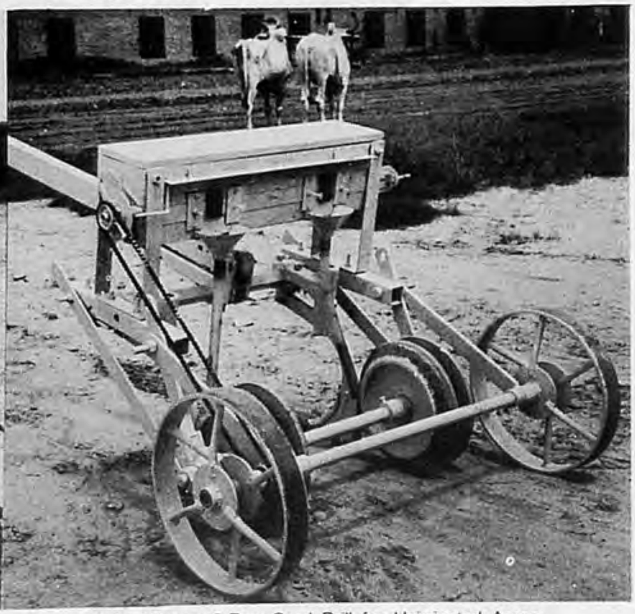
The angle included by the wings of the sweep ranges from 60 to 90°. The smaller angles shed trash better but require excessively long wings for sweeps with wide cuts. Under average conditions the V-angle is limited to 60 to 65°. With a 60° to 65° included angle, the wings of the sweep have sufficient backslope to permit trash that may become lapped across them to slide backward and clear the sweep.

The pitch or angle of the blade to the horizontal should be steep enough to pulverize the soil moderately but should not be so steep as to cause ridging of the soil or excessive covering of crop residue. With a blade 10 cm wide the back margin of the blade should be raised approximately 3.5 cm. For a 4 cm wide blade the pitch is about 1.2 cm. If the blade is flat, it will slip through the soil, disturbing it or the vegetation very little, but if the pitch is excessive the draft requirement will be high and clogging of blades are likely to result.

The sweeps are adjusted to run flat. Penetration is obtained by the suction on the point and the pitch of the blade, and to a certain extent through the weight of the frame. For effective operation the sweeps are arranged in two rows on a frame and are staggered. To obtain a good weed kill the paths of the sweeps in the two rows should overlap by 7 to 10 cm. To suit intercultivation, full sweeps and half sweeps (having one wing only) are arranged to match the crop rows. With tractor operated cultivators using large sweeps, the front row of sweeps should be at least 45 cm ahead of the back row. When a closer spacing is used insufficient space remains between the sweeps in the two rows, resulting in the clogging of trash and debris between the sweeps. A clearance of about 45 cm between the bottom of the sweep and the frame is desirable to provide sufficient throat clearance.

Stubble mulch tillage is based on merely stirring the soil with implements that leave considerable part of the vegetative material, i.e., vegetative litter and crop residues on the land surface

Rear View of a Tractor-Drawn Seed Drill for Unirrigated Areas



Animal-Drawn 2-Row Seed Drill for Unirrigated Areas as protection against erosion and for conserving moisture by favouring infiltration and reducing evaporation. The primary function of stubble mulch is to protect the surface from erosion by putting obstacles in the path of wind or water and to conserve moisture. This operation is suitable in limited low rainfall areas in India which are subjected to wind erosion. A stubble mulch, under the circumstances, will be effective in producing the desirable effects of moisture conservation and erosion control.

Tillage machines vary greatly in their capacity to keep residues on the surface. Some residue will be covered each time the land is worked regardless of the type of implement used. Cultivators equipped with V-shaped sweeps are effective in stubble mulch farming. One-way disc harrows and rotary hoes are also sometimes used, mould board ploughs, disc harrows and shovel cultivators are the least suitable as they cover a large portion of the crop residue. Implements for stubble mulching should be capable of cutting through heavy crop residues under unfavourable moisture conditions and leaving the residues well anchored and standing if possible. Seedbed preparation and planting are done in as few operations as possible. Repeated operations result in the covering of the vegetative matter and increased erosion hazard and evaporation losses. Shallow working tools may be used a minimum number of times for preparing the seedbed, during planting and intercultivation.

Seeding Equipment

The seeding equipment for unirrigated areas are designed to place the seed in firm moist soil. The moisture in the surface layer of the seed bed in dry areas is evaporated quickly. Germination of seeds may be adversely affected if the seeds are sown at shallow depths of 4 to 5 centimetres as in irrigated areas. However, the soil moisture at deeper depths may be sufficient for successful germination of seeds. Deep sowing with a conventional seed drill will result in too deep placement of seed and poor germination. Therefore the requirements of seed drills for unirrigated areas are that it should make a furrow in the dry soil layer and place the seed in firm moist soil below the bottom of the furrow. The multi-row seed drills with packer wheels (tractor-drawn and animal-drawn) shown in the accompanying figures are designed to obtain the optimum environment for the germination of the seed and growth of the seedling under unirrigated conditions. The seed boots are designed to place the seed about 4 cm below the bottom of the furrow made in the dry soil layer. Packer wheels fixed to the rear of the machine pack the soil over the seed. A chain driven toothed wheel fixed to the drive shaft of the seed dropping mechanism can be set to obtain the desired seed to seed distance in sowing. The wheel actuates the flap gates provided at the seed dropping mechanism. The seeds drop out every time the gate is open. By fixing wheels with different spacings of teeth, any desired seed to seed distance can be obtained. This feature makes the seed drill suitable for sowing close growing crops like wheat and row crops like maize, cotton and sorghum.

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A Field Sown with a Seed Drill for Unirrigated Areas.

An Animal-Drawn 2-Row Intercultivator for Flat Sown Row Crop. Note The Arrangement of Half Sweeps and Full Sweeps

THE MERRY TILLER

as a Practical Farm Machine for *Korea*

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(Seeding with Merry Tiller)

Farm mechanization in Korea was greatly accelerated by the government during the First Five Year Economic Development plan begun in 1962. During both the First and Second Five Year Economic Development Plans, the farm machinery distribution was increased rapidly. In 1971, 5,000 power tillers were produced, and the distributed number were 17,000. Especially, the government had managed to set up the feasibility study of farm mechanization of Korea by foreign research team in 1971. With this as a turning point, Korean farm mechanization is expected to be regularized in the future.

The government has started to spread the new rice variety IR 667 through the country. As the IR 667 has a short stalk, long grain and is easy to scatter, there are many problems to be solved in redesigning, manufacturing and supplying the farm machinery to be suited for the characteristics of the new rice variety.

I will describe the power tiller which is taking the most important leading role among many kinds of farm machinery and also the merry tiller for the Korean farming condition.

I. The Present Status of the Power Tiller

The domestic firms started producing the power tiller in 1962 and they were distributed by the National Agricultural Cooperatives Federation with government subsidies and credit. 17,000 power tillers were supplied by 1971, and it has been planned to keep supplying farms with them. However the distributed power tiller is manufactured by the Dae Dong Industrial Company, in technical cooperation with the Mitsubishi Company in Japan, is the only kind, since the Dong Yang Gear Company has quit producing tiller. The Jin Il Company is planning to manufacture them in technical cooperation with Yanmar Company in Japan.

The early models, smaller in horse power (6H.P.) were changed to higher horse power models (8H.P. to 10H.P.). The trend of distribution of power tillers shows rapidly increasing rates as indicated in **Figure 1** and will keep increasing. In 1970, the National Agricultural Cooperatives Federation received 3,581 more applications for tiller than were available and in 1971, 7,000 more applicants wanted to purchase power tiller than were available. There are several factors encouraging the new demand for power tillers. The first factor was the recognition by the farmers that the power tiller improved their yield. The second factor was that the buyers, as well as farmers benifitted from government subsidies. The third was that the incomes from the power tiller used in transportation can not be ignored in the smaller cities. Therefore the small horse power of the power tiller has increased from 6H.P. to 8H.P. to 10H.P. because of the demand. The price has also increased from 140,000 Won in 1963 to 400,000 Won as of now.

However these aspects could be changed: first, the government subsidies could be discontinued from 1972, secondly, the tiller could be used in farming and not for the purpose of transporting, thirdly, the tiller could be popularized not only for the rich farm but for the poorer farms. With such a point of view, the small horse power tiller, around 5H.P. such as the merry tiller, could be used for popularized distribution as well as the higher horse power tillers.

2. The Merry Tiller

The merry tiller must be designed to suit the Korean farm situation: First, the price must be moderate. Secondly, the merry tiller attachments, which enable farmers to do multiple purpose work, are needed. It must be possible to do farm work lightly. Another thing that is needed is a government subsidy for at least five years as was done with the power tiller. This should continue untill the farmers recognize the value of the merry tiller because the farmers are hesitant to purchase new machinery which has mechanically lower efficiency than the higher horse power engine tiller. In order to remove the weak point in the use of the merry tiller, continuous study for designing and problems in manufacturing is needed. The power tiller, which has a high horse power (10H.P.) engine, is sometimes uneconomical in doing farm work that requires small horse power such as pumping, spraying and threshing. Therefore the merry tiller with small horse power engine as 5H.P. or below is sometimes more profitable than the power tiller. We must develope a small horse power engine tiller like the merry tiller to suit Korean farming conditions.

3. The Comparison of the Power Tiller to the Merry Tiller

The 5H.P. merry tiller and 8H.P. power tiller was compared on the efficieny and economic analysis in 1970. The results are shown in the following **tables 1, 2, and 3.**

Table 1. The Structure

Item	8 H.P.	5 H.P.
Engine	K 8 A	SG 5C-S
Total Exhausting Amount	667 c.c.	287 c.c.
Break Horse Power	8 H.P. / 2,000r.p.m.	5 H.P. / 1,800r.p.m.
Maximum Break Horse Power	11 H.P./ 2,200r.p.m.	6 H.P./ 1,900r.p.m.
Fuel	Kerosene	Kerosene
Engine Weight	110 kg.	37 kg.
Fuel Tank Volume	8 liters	5.2 liters
Lubricant Volume	2.2 liters	1.0 liters

The results of comparison of 8H.P. power tiller and 5H.P. tiller is as follows.

1) It was found that the optimum size of horse power for the present Korean situation is 5 to 6. The experiment was conducted with an 8H.P. an a 5H.P. tiller by plowing and harrowing barley on a paddy field after rice was harvested.

2) If the farming method by

Figure 1. The Rate of Power Tiller Introduction in Japan, Taiwan and Korea
Per 1,000 hectares of paddy field (semi-log scale)

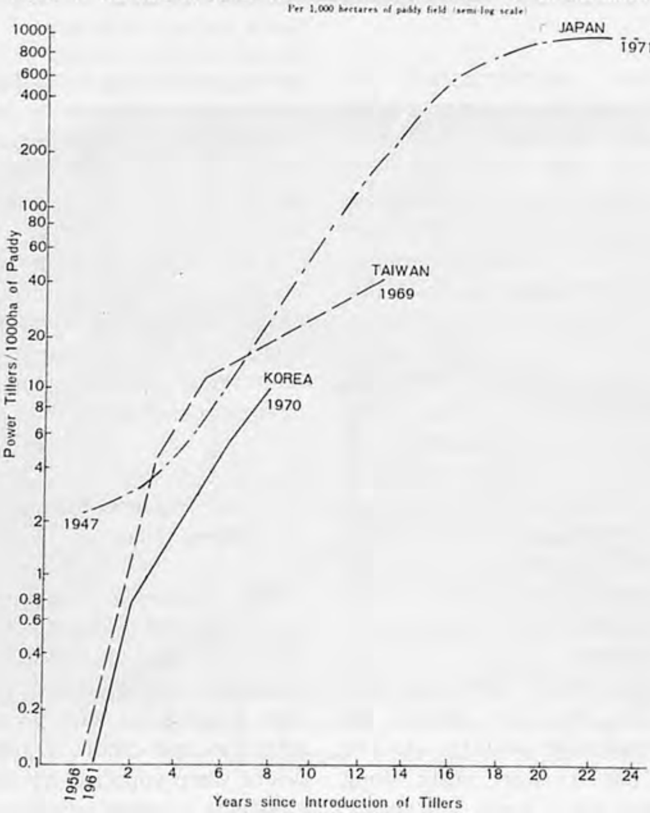


Table 3. Economic Analysis Unit: Won

Item		8 H.P.	5 H.P.
Purchasing Price		364,000	200,000
Depreciation		46,800	25,710
Repair Expenses		21,840	12,000
Interest		24,024	13,200
Plowing Cost per 10 a	fixed cost	329	189
	floating cost	334	302
Harrowing Cost per 10 a	fixed cost	87	62
	floating cost	88	97

Data: The Agricultural Engineering Utilization Institute, The Ministry of Agriculture & Forestry/ Korea

the rotary plow has improved, the 8—10H.P. power tiller would be better. However if a tractor would be supplied along with the 8H.P. power tiller, the 5—6H.P. would be more useful.

3) In the plowing, 16.5cm of plowing depth of the 8H.P. power tiller was shown superior to the 15cm of plowing depth of 5 H.P. tiller, but in operating as it was easier to handle the 5H.P. tiller. The utility of the 5H.P. tiller would be greater than the 8H.P. power tiller.

4) The 5H.P. tiller was more economical.

4. Conclusion

The target of farm mechanization is to popularize farm machinery—the most suitable farm machinery for the farmer's land. In order to distribute farm machinery suitable to our farming needs and economic situation, a thorough study is needed. Farm machinery, which is suitable to Korean farming methods and economic situatimn, must be developed for the mass supply. To manufacture inexpensive farm machinery, is the most important problem. For instances, a 50H.P. tractor is suitable to the farming situation of the United States whose G.N.P. is 3,000 Dollars. In Japan, on the other hand they used the 4—5H.P. small horse power merry tiller in 1950 when the G.N.P. was 200——300 Dollars. As the Japanese G.N.P. increased to 1,800 Dollars, the small horse power tiller began to change to a 15—25H.P. riding tractor. In this aspect, the 4—5H.P. merry tiller is suitable to present situation of the Korean farm, considering the operating technique of the farmers and their income. It is probable that with the increase in the farm income of Korea, a corresponding in H.P. will result like Japan.

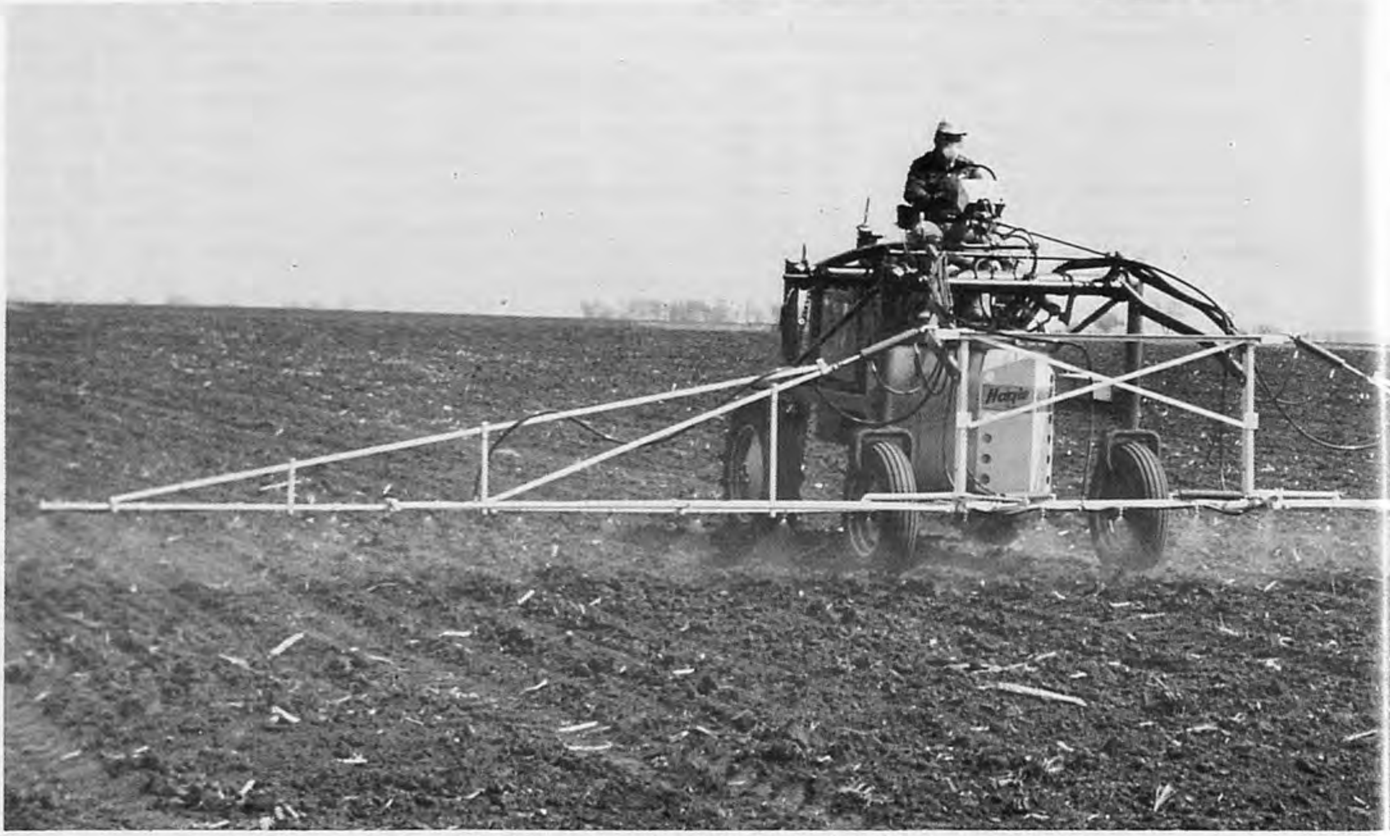
It is desirous to manufacture the merry tiller, which is suitable to Korean farm conditions. It can be improved with new manufacturing techniques. It would be also possible to get successful distribution of the merry tiller through the country, if the tiller was produced in masses and coincided with government subsidation along with the operating and repairing technique farmers. ■■

Table 2 The Results from Operating Experiments

Item			8 H.P.	5 H.P.
Plowing (plow)	Plowing Depth	paddy	16.5cm	15 cm
		upland	16.3 〃	15 〃
	Plowing Width	paddy	22 〃	20 〃
		upland	22 〃	20 〃
	Time Required	paddy	128 min.	134 min.
		upland	123 〃	129 〃
Furrowing for Barley	Plowing Depth	paddy	15.5cm	15 cm
		upland	16.5 〃	15 cm
	Plowing Width	paddy	22 〃	20 〃
		upland	22 〃	20 〃
	Time Required	paddy	92 min.	119 min.
		upland	88 〃	117 〃
Rotary Plowing	Plowing Depth	paddy	14 cm	12 cm
		upland	14 〃	12 〃
	Plowing Width	paddy	60 cm	60.6 cm
		upland	60 〃	60.6 〃
	Time Required	paddy	34 min.	44 min.
		upland	28 〃	39 〃
Furrowing paddy for Barley*	Plowing Depth		14 cm	12 cm
	Plowing Width		60 〃	60.6 〃
	Time Required		40 min.	54 min.
Working Rate	Ordinary Speed (4th speed)		47km/hr	5km/hr
	Maximum Speed (6th speed)		13km/hr	18km/hr
Loading Amount	Ordinary Loading Amount		500 kg	300 kg
	Maximum Loading Amount		1,000kg	600 kg

* Rice field that was harvested and replanted with barley

New WEED Control Equipment



(A large, multi-row, self-propelled sprayer. Note operator wearing respirator, goggles, and gloves.)

The early nomadic tribesmen who first attempted to raise a crop were also first to become acquainted with an unwanted intruder. The pest that appeared in their fields, today, more than ever, plagues agriculture worldwide. Despite chanting incantations, wielding the hoe,and applying scientific methodology, man continues to suffer the ravages of weeds.

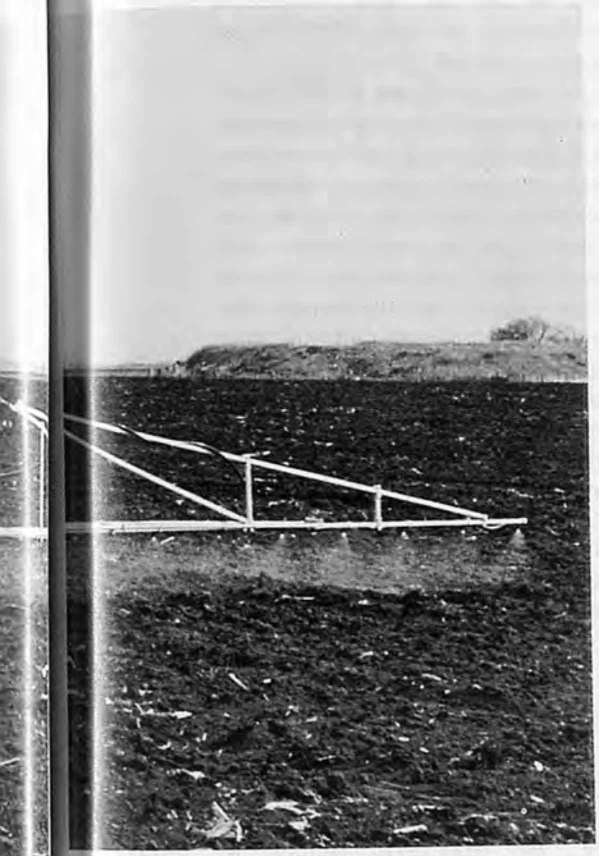
Since "weeds will grow under any flag if only the conditions they demand are favorable"(8), weed control and prevention should be global concerns. Weeds have, in fact, come under an accelerating worldwide attack as man's awareness of the problem and its' dire implications has come into focus. Weed science has emerged from the twilight of semi-science. Under the assault of renewed research efforts, innovative new weed control methods and devices have appeared ranging from improved basic tools to highly sophisticated technology.

Weeds have earned their unsavory reputation through a panoply of objectionable characteristics. They aggressively compete with crop plants for all the inputs to a field: sunlight, soil moisture, and soil nutrients. If uncontrolled, weeds have the capacity to totally overcome crops, or at least to interfere with cultural and harvesting operations plus contaminate the harvested crop with weed seed.

Weeds can emit noxious pollen, poison livestock, destroy pastures, or act as hosts for crop invading (and, in some cases, man attacking) insects, diseases, and other predators. Weeds can obstruct vision along roadsides, pose severe fire hazards, hasten the rusting or rotting of structures, and cause man painful skin ailments. Weeds can block irrigation structures, hamper navigation, or suffocate fish. In short, weeds make precious little contribution to man's total environment.

Agriculture has been defined as a "controversy with weeds"(10). Quite likely it was a passive controversy for the nomads and other early agriculturalists who paid little attention to weeds, or considered them as a nuisance to be tolerated. As agriculture evolved into a more scientific pursuit and applied research started to develop information, a body of knowledge began to emerge substantiating weeds as no mere nuisance, but as undesirable culprits capable of costing the world billions of dollars each year(8). The same data dramati-

and Techniques



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cally showed that prevention and control of weeds equated with increased crop yields.

Control of Weeds

Through the first four decades of the 20th century, those farmers who attempted to control weeds were limited to the use of fire, flooding, mulching, or mechanical means. The latter involved either a hand-held tool, or pulling a cultivating implement behind an animal (or mechanical power source). Fire tended to be unmanageable and flooding was out of the question for the majority of non-Asian farms. Both chopping and cultivating were basically reliant on visual detection of weeds before removal could occur, thus permitting weed growth to compete with crop plants during the critical period of establishment. Crops, as well as target weed plants, suffered injury, if not unintentional removal, during chopping operations; stirring the soil surface via cultivation often resulted in the escape of valuable soil moisture.

A milestone in the crop-weed controversy occurred with the discovery, research, and development of compounds capable of adversely affecting certain species of plants, but not others. Selective herbicides were born, and with them agriculture gained its most effective tool for battling the old, well entrenched enemy.

The current worldwide emphasis on increasing agricutural yields has generated renewed impetus for efficient farming and acute pressures to maximize production from every hectare under the plow. One immediate result has been increased applications of fertilizer and water to stimulate crop production from recently introduced new high yielding crop varieties. A less beneficial result is the accompanying surge of weed activity. Agriculture is therefore faced with the dual necessity of not only increasing inputs, but also emphatically moving to eliminate the staggering losses caused by weeds.

Weed Prevention

Weed caused crop losses can be reduced by the simple, but all too often ignored concept of weed prevention. Like fire prevention, weed prevention attempts to anticipate problems before they occur by eliminating the potential sources of trouble. Weed prevention involves limiting the spread of existing weed species and, even more critical, blocking the introduction of new weed species to an uninfested area. Unceasing awareness, concern, and cultural hygiene by agriculturalists will significantly expedite a prevention program and pay dividends in controlling weeds.

Specific steps to be taken (adapted from Crafts and Robbins[3]) are:

1. Carefully inspect incoming crop seed lots and only plant those lots that are free of weed seeds.

2. Thoroughly clean tools, tractors, and other implements before moving them from one area (especially if weed infested) to another.

3. Keep irrigation ditch banks weed free.

4. Keep all uncropped areas -- fence lines, roadsides, farmyards -- weed free.

5. Inspect incoming nursery stock for presence of weed seeds, tubers, or rhizomes of perennial

weeds.

6. Do not move livestock directly from infested areas to clean (uninfested) areas.

7. Do not use manure from livestock that have been fed screenings, grain, or hay containing weed seeds.

8. Exercise extra caution when operating in infested areas at times of seed maturing and dispersal by inspecting and cleaning all exposed equipment and clothing.

While individual farmers may perform the actual work associated with the eight steps above, overall community awareness, agreement, and support are vital to implement truly effective weed prevention.

Designing a Weed Control Program

Since there is little evidence to suggest that many agricultural areas operate without some weed problems, weed prevention--as the first line of defense--must be backed up by appropriate weed control programs. Kasasian(7) notes that in tropical agriculture, "some measure of weed control is almost always necessary."

Two broad types of information are necessary in order to design a proper, long range program: physical data, and socio-economic evaluations. Obviously the various weed species present and crops grown need to be identified. Also, information concering soil characteristics, terrain, irrigation (if practiced), and weather patterns needs to be collected.

Less obvious are the social and economic factors that nontheless may directly influence the scope and implementation of weed control. Parker(13) has stressed that a "concern for society" must be kept in mind and that the full range of agricultural activity, from subsistence farm to corporate enterprise, must be considered. Labor availability, or lack of it, during the short but critical periods when crops are manually weeded, will have a direct bearing on planning for weed control.

Labor costs versus equipment costs; the value of estimated yield loss occurring in unweeded crops versus the net increased income from weeding; cost of herbicides; materials availability; all the intertwined economic factors warrant investigation and resolution prior to initiating any extensive weed control program.

Mechanical or Chemical

The practices of chopping and cultivating have already been mentioned as traditional methods of weed control and both may still have beneficial uses depending on local conditions. If various economic or social constraints preclude use of chemical methods for weed control, then mechanical methods must be seriously considered. Some weed control is generally better than none.

Cropping under controlled moisture (irrigation) compared with uncontrolled (rainfed) holds greater potential for mechanical weed control; cultivation can be timed for maximum effectiveness. Also, a short growing season is not as well suited to mechanical control as a longer growing period.

If, after studying all the various elements affecting agriculture in a specific area, indicators support a weed control program involving herbicides, either exclusively or in combination with mechanical methods, the selection of equipment and techniques that might be employed can still pose a mind boggling dilemma. Herbicide applicators, as an example, range from a simple, hand carried tube that will dribble out granules, to highly sophisticated aircraft utilizing electronic guidance systems. The great bulk of equipment falls between these extremes.

Equipment Selection

Even after determining the general type of equipment best suited for a particular situation, the task may still remain to select a model from among many that are available in any one category of applicator. A recently published manual of pesticide application equipment(4) lists 33 different manufacturers of powered, back-pack combination dust and liquid sprayers, and many of the firms offer more than one model.

The vast array of available makes and models, in this case, attests to the popularity of small, powered combination sprayers with their inherent flexibility, relatively low cost, and suitability for a variety of farming operations. Most sprayers of this type utilize compact gasoline engines to drive a high speed blower and generate an air

Fig. 1 A tailboom fitted to a compressed air, knapsack sprayer permits the operator to continually move away from the area just sprayed.

stream. The pesticidal material is metered into the air strem, dispersed, and blown onto the intended surface.

Tailbooms

Those few powered knapsack sprayers having positive displacement pumps, plus the hundreds of models of manually pumped knapsack sprayers and compressed air knapsack sprayers, generally discharge liquid from a spray tube fitted with a nozzle, or utilize a spray boom and multiple nozzles. Ejection of spray usually occurs ahead of the operator who, as he moves along, continually passes through the area just sprayed. Fitting a tailboom (**Fig. 1**) where possible, permits the operator to always travel away from, instead of through, the sprayed area. Vertical tailbooms are also available for spraying taller crops such as grapevines.

Nozzle hoods

General contact herbicides, compounds which are not selective and which affect all plants, must obviously be kept off growing crop plants. A variety of shields, hoods and guards can be used to limit spray when operating with this type of herbicide. Some hoods are directly attached to the nozzle or spray tube; others come between the nozzle and the crop (**Fig. 2**).

Peristaltic pump

The peristaltic form of pump (**Fig. 3**) may be useful for some sprayers. The illustrated unit is typical in that as it moves forward, three knobs attached to its ground wheel revolve while periodically in contact with a flexible tube, forcing spray liquid to flow from a plastic tank to the discharge nozzle. There is an obvious saving in weight and gasoline consumption compared with an engine powerd sprayer. However, a peristaltic sprayer would be unsuitable for use in rough terrain.

Herbicide glove

The Weed Research Organization (WRO) in England has developed a truly manual applicator, a herbicidal glove used for treating isolated weeds not easily treated by other means in the presence of a crop. The glove is intended to reduce the labor of hand pulling weeds which either escaped an earlier herbicide treatment or were not observed until visible above the crop. Prepared herbicide is gravity fed to the glove from a back-pack tank. The operator uses the glove to smear weed seed heads with herbicide and reduce the viability of the seed. For grassy weeds, densities of 2,000-3,000 panicles per hectare can be treated with ease and higher densities could seemingly be managed without too much difficulty(6).

Equipment Design Trends

There are several important general trends in the manufacture of herbicide application equipment, prime among them being the effort to build in features that will increase control and accuracy of material placement. Positive shutoff valves to eliminate after spray dripping, convenient location of equipment controls, as well as features that insure and expedite complete system clean-out exemplify contemporary design thinking.

The use of fiber glass, plastics, and other materials which are both corrosion and impact resistant, and relatively lightweight, has been broadly adopted. Overall simplicity of operation and design functionality have received increased emphasis. While some units are offered for a single, specific use, others have ingenious options that can expand the basic machine's applicability to a variety of weed control situations.

Power sprayers are now available in sizes ranging from the small, knapsack, man-carried units (mentioned above) to multirow monsters in a variety of mountings, including self-propelled (**Fig. 4** = on the heading). One firm offers a power sprayer unit mounted on an air supported pallet capable of frictionless travel over ground, marsh lands, or mud (**Fig. 5**). Its use for plant


Fig. 2 Guards mounted on wheels limit spray.

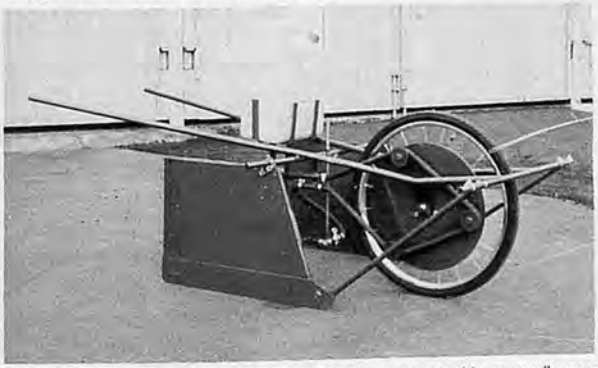
Fig. 3 A peristaltic pump supplies spray to a single nozzle on this manually propelled sprayer.

Fig. 5 A sprayer can be mounted on an air supported pallet which can move frictionlessly over a variety of surface conditions.

protection in flooded paddy areas presents interesting possibilities.'

Low volume spraying

Another form of liquid applicator that has received a lot of attention recently is the low volume sprayer. Whereas water is usually required to dilute normal spray, low volume machines function with undiluted liquid herbicide which is dispersed in minute amounts. Interest in the technique stems from the lower volume of spray emitted and an attendant decrease in chances for spray drift or other environmentally objectionable occurrences. The low volume unit illustrated **(Fig. 6)** mixes herbicide with pressurized air and emits a spray swath under the hooded chamber. It is designed for pasture or range land weed control, or preemergence row crop spraying.

Spray trap

One research team has developed a prototype liquid sprayer for applying herbicide to weeds taller than a crop(9). Solid stream nozzles located above and at right angles to crop rows spray inward toward a center mounted trap which collects any liquid not deposited on the weeds. The entrapped solution then flows back to the sprayer's tank for recirculation. The unit permits utilization of herbicides normally considered toxic to crops, but needed for control of certain noxious weed species. A cost reduction can also be realized from recovery and reuse of spray not intercepted by weeds. The unit was originally built to test late postemergence weed control in soybeans.

Layering

Precise placement of soil incorporated liquid herbicides can be achieved by layering or blading(2). A spray blade attached to the tool bar of a tractor travels at a pre-set depth below ground surface. Nozzles on the concave underside of the blade eject spray resulting in a concentrated layer of herbicide. The procedure has proven effective on certain weed species in some orchard crops.

Aquatic weed control

An increasing amount of attention is being devoted to control of aquatic weeds, and not without due cause. Besides being capable of growth in flooded fields, aquatic weeds choke irrigation canals, interfere with navigation, harbor disease bearing insects, suffocate fish, and cause other indirect problems for agriculture. New technology has been applied to aquatic weed control as evidenced by some of the recently designed water weed cutters.

One unit **(Fig. 7)** features a double skin fiber glass hull, independently driven propulsion paddles, and a fully hydraulic cutter bar. Twin paddles, each driven by a separate hydraulic motor, "walk" through heavy weed growth or cuttings without clogging or jamming. Flexible knives on the U-shaped cutter bar oscillate against a fixed knife similar to that found on reciprocating grass/crop mowers. The cutter is also hydraulically driven and adjusts for depth of cut, may be raised or lowered, offset for clearing banks, tilted, or reversed for cutting in the opposite direction. Plastic foam filling in the hull provides buoyancy, and flip-up floats fore and aft allow turning in narrow waterways.

Researchers in Canada have devised a simple carbon dioxide pressured herbicide sprayer for use in small scale aquatic spraying programs(1). The unit consists of a CO_2 pressure tank, pressure regulator and gauge, herbicide tank, spray tube and nozzle, plus valves and hose. Material can be either applied to the water surface, or subsurface injected at depths to 3.3 feet (1 m) or more, depending on where aquatic plants may be growing. Results have been encouraging.

Spray aircraft

"Crop care by air," a term originally applied to seeding and insect control, now also covers weed control techniques. An Australian firm currently produces one of the more innovative agricultural aircraft, a machine specifically designed from wheels to wings for aerial application of chemicals(5). It carries a spray boom of less than 40 feet (12 m) length, but achieves a treated swath of 90 feet (27 m). The configuration of wings, tail, engine, cockpit, and chemical tank are totally compatible and entirely functional. Loading of spray material is accomplished rapidly, mechanically, and with minimum chance of spillage, waste, or human contact.

Spray Drift

No matter whether chemical materials are applied from land, water, or air, the act must be accomplished in a manner so as to provide maximum protection to those humans doing the applying as well as other humans, livestock, and plants in the surrounding area. The threat (and occurrence) of spray drift constitutes a major problem for, and serious deterrent to, the use of sprays or dusts. A slight breeze during spraying operations can drift spray from its intended target to adjacent fields or orchards with possible effects ranging from absolutely no damage to total devastation.

A great deal of research has been directed toward reducing the incidence of chemical spray drift. One of the more promising developments involves mixing a foaming agent with spray liquid and ejecting the mixture through special foam nozzles. The agent, a special spray adjuvant which also carries increased wetting capabilities, together with the foam nozzles cause the spray to emerge in larger, foamy droplets that are much less susceptible to drift than smaller, normal spray droplets. Foam spraying is also claimed to use less actual spray and do a more thorough job of penetrating dense vegetation.

Using Nonselective Herbicides

Herbicides are generally either selective--effective against certain plant species and harmless to others--or nonselective, the latter being toxic to all plant growth. Naturally nonselective herbicides are effective against a much wider spectrum of weeds; for obvious reasons, they cannot be used in cropping areas, unless an existing or future crop can be protected in some manner. Researchers at Oregon State University (US) have developed a promising crop protection method utilizing activated carbon as an adsorption agent for nonselective herbicides[12].

It works as follows: when the crop is planted, a special device applies a narrow band of activated carbon directly over the seed row. A nonselective, broad spectrum herbicide is then applied to the entire field. The activated carbon has physical properties which allow it to absorb the herbicide so that when the crop seedlings emerge through the carbon, they do so unaffected by the herbicide, whereas in all the surrounding between row ground surface, weed seedlings are eliminated as they come in contact with the soil borne herbicides.

A form of soil "first aid" has also been investigated; herbicide treatments incorrectly applied to the soil have been corrected by tilling in activated carbon which then adsorbed the herbicide, thus cancelling its affect.

Other Application Methods

"Fertigation" is a hybrid term coined for the simultaneous application of fertilizer with irrigation water. Now the state of the art has advanced and some growers are practicing "herbigation," the injection of selective herbicides into sprinkler (and surface) applied irrigation. For sprinklers, rolling or large center pivot systems appear to have the best potential for this technique which could prove useful under certain conditions. The injection equipment works in conjunction with the sprinkler pressure system.

Fig. 6 Low volume spray is ejected under the hood of this trailed sprayer.

The simultaneous field application of plant food (fertilizer) and herbicide has become known in the US by the phrase "feed and weed." Two compounds may be applied in one pass over a field or crop, or a single dual purpose material may be utilized. Researchers have also been investigating the feasibility of incorporating herbicide into pellets of chemical fertilizer.

Various forms of non-tillage, or minimum tillage, are being practiced for several reasons, including weed control. Instead of discing under the remains of a previous crop, growers apply the proper herbicide (or mixture of herbicides) to halt crop regrowth as well as weed germination during a period of fallow. The field surface remains firmer than if tilled, thereby allowing earlier entry into fields after the rainy season and direct planting of the next crop in the undisturbed ground. Farmers in some regions can plant, fertilize, and apply herbicide in one pass over a field.

Experiments performed in Japan have utilized plastic sheets, which were either coated or impressed with various herbicides, as a much for upland rice(11). Most of the herbicides tested were activated in the soil within one day after mulching. Rates of application only two-thirds that normally required were effective because of higher soil temperature and moisture content. Paper, too, has been impregnated with herbicide and buried in the soil in an attempt to achieve a time-release herbicidal effect.

Biological Weed Control

In addition to mechanical and chemical means of weed control, a third method holds great promise and is gaining increased attention: biological control of weeds involving the use of insects and other natural predators, such as geese and certain species of fish. The benefits of a successful biological weed control program could be immense in terms of financial saving and reduced risk of mis-applied and mis-handled chemicals. The other side of the coin carries the frightening implications of weed predators turning out to be less selective than believed when introduced to crops, or any one of several other undesirable situations that might be impossible to predict from relatively limited experimentation.

A dedicated group of scientists worldwide continues to search for effective predators that will, like some chemicals, be highly selective and only attack weedy plants. Integrated weed control techniques, a combination of biological and chemical methods, are also receiving careful attention.

The world has recognized that weeds pose a threat to agriculture and can exert a direct and very evident negative effect on man's food and fiber supplies and ultimately, his welfare. One weed control scientist, researcher, and teacher(10) have put it succinctly: "The efficient practice of weed control using the most modern techniques and tools available could advance world food production more than any other single practice." ■ ■

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Fig. 7 Fiber glass and hydraulics are features of this water weed cutter.

A Direct circulation rotary drilling rig for medium size tube well. Casing pipes are in the foreground and a compressor unit on the left side

Equipment Needs for Irrigation Development in India

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The limited water resources of India have to be harnessed to match the needs of food and fibre for the growing population and increased industrialisation. Adequate availability of the required equipment play a vital role in the planned development and use of the water resources of the country. Appropriate and efficient equipment are required for the construction of irrigation works such as dams, canals and tube-wells. Large number of engines, electric motors and pumps are needed specially to exploit the ground water. Water regulation and measuring devices can help in the efficient utilisation of irrigation water. Sprinklers and drip irrigation methods are being used for economising water and labour. Irrigation equipment is needed at all stages of irrigation development and water utilisation.

Irrigation development

The average annual rainfall of the Indian sub-continent is 110 cm with a range from 20 to 400 cm. Major part of this rainfall comes during the four months of monsoon from June to September. The country is blessed with adequate sunshine and temperature to grow crops all the year round. Generally two crops are raised, one during the monsoon from July to October and the other during the cooler months of the year, from November to March. The monsoon crop is generally a rainfed crop in most parts of the country, but due to the indefinite and erratic nature of the rains, crop failure is not uncommon. The amount of rain during the winter crop is inadequate and therefore, the dependence on irrigation is usually imperative for this crop. I view of these climatic factors it is essential for India to have dependable irrigation supplies.

The total geographical area of India is 328.048 million hectares, out of which the net area sown was 140 million hectares in 1967-68; the net and the gross irrigated areas being 27.52 and 33.13 million hectares, respectively. Thus about 20% of the cultivated area was having irrigation facilities during 1967-68.

The total annual surface runoff in rivers and streams of the entire country is estimated to be about 167 million hectare-metres per year. The total annual recharge to the ground water has also been assessed to be about 42.5 million hectare metres. The entire surface runoff and the recharge to the ground water are not available for irrigation development because of the limitations due to dependability of flows, storage facilities, nature of use, quality of water, losses in evaporation and transit etc. In consideration to these factors, the utilisable quantum of surface water is estimated to be 66.6 million hectare-meters per year and from the ground water 20.4 million hectare-meters per year. It is thus estimated that the country's total utilizable water resources can be placed at 87 million hectare-meters per year.

Soon after independence, in 1947, India faced severe food shortage due to famines. In 1950-51 the total food grain production was only 54.92 million tonnes for a population of 361 million.

Table 1: Development of Irrigation in India (1951-1971)
Potential at the end of each period in million hectares

	Pre-Plan	First Plan (51-56)	Second Plan (56-61)	Third Plan (61-66)	1966-69	1969-71	1973-74 (Target)
1. Major and Medium Irrigation	9.67	12.15	14.30	16.93	18.54	19.65	23.33
2. Minor Irrigation	12.88	14.05	14.78	17.00	19.12	20.21	22.23
Total	22.55	26.20	29.08	33.53	37.66	39.86	45.56

Realising the urgent necessity to increase agricultural production, planned efforts to rapidly extend irrigation facilities were started. The realistic planning on irrigation substantially contributed in stabilising the food situation of the country. The classification of works in the categories of major, medium and minor irrigation projects are based on financial limits on expenditure involved in the schemes. Major projects are those costing more than Rs.50 million, medium projects cost between Rs.50 million and 2.5 million and the minor projects cost less than Rs.2.5 million, individually. The minor schemes consist of irrigation tanks, canals, diversion works, anti-sea intrusion works and almost all the ground water schemes. **Table 1** gives the development of irrigation in India during the past two decades. **Figure 1** gives a proportionate idea relating to the development of irrigation and also the anticipated exploitation upto the year 2000~01.

By the end of March 1969, India completed three Five Year Plans and three Annual Plans. During these plans 537 major and medium projects were taken up, of which 80 were major projects. During the Fourth Five Year Plan, 4 major and 24 medium schemes have been sanctioned. Minor irrigation works, specially the ground water schemes, have also been receiving greater attention with the inception of the Plans as these schemes have the inherent advantage that they are for individual farmers or for a group of farmers. The supply of water can be regulated according to the wishes of farmer, depending upon the needs of the crop and area to be irrigated. The tempo of progress of the ground water schemes was specially accelerated during the period 1966~69. The progress which was only about 3% per annum up to 1965~66, attained a high level of 10.5% during the three annual plans i.e. 1966~69. This high rate of growth is explained by the advent of high yielding crop varieties, mobilisation of institutional resources for financing the programme, stepping up of rural electrification programme and the merit of ground water in securing freedom from droughts and famines. Availability of

Table 2: Progress in ground water utilization programmes

(number in thousands)

Sl. No.	Item	Pre-Plan	End of the period: I Plan (1955-56)	II Plan (1960-61)	III Plan (1965-66)	Tri-annual Plans (1968-69)
1	Open wells	*	3642	4474	5111	5707
2	Boring of open wells	*	*	109	245	507
3	Deepening of open wells	*	*	14	101	216
4	Diesel pumps	66	123	230	465	650
5	Electric pumps	19	50	192	514	1021
6	Private tube wells, including filter points	21	30	49	113	271
7	State tube wells	3	7	10	13	16

* Not available.

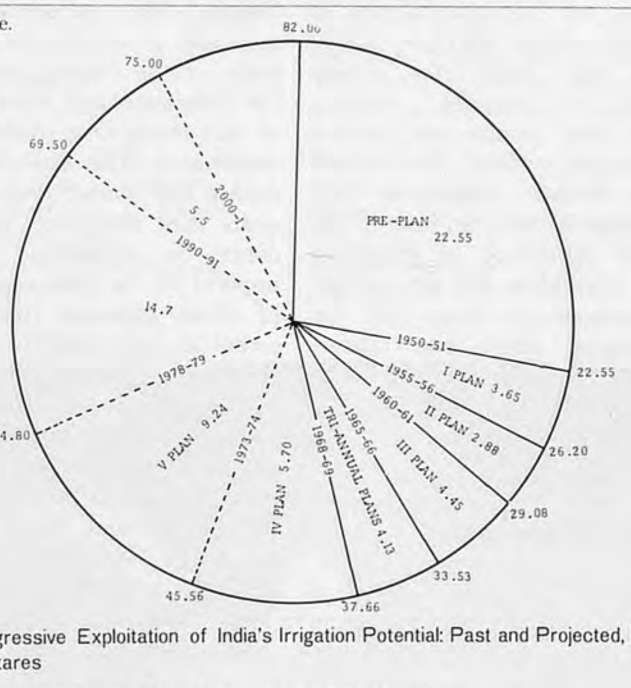

Fig.1 Progressive Exploitation of India's Irrigation Potential: Past and Projected, Million Hectares

Fig.2 An artesian tube well discharging about 150 litres per second in the Terrai region of the State of Utter Pradesh

ground water depends upon the aquifer conditions in different hydrogeological regions of the country. A high discharge artisian tube well may be seen in **figure 2.** The successive progress of ground water works through the plan periods is detailed in **table 2.**

In India, ground water development has been taking place through various agencies such as the Central Government, State Governments, financing institutions and private agencies. The development of ground water during the Fourth Five Year Plan (1969-74) has been taking place at a steady rate of progress. The figures in **table 3** indicate the average magnitude of ground water expansion per year.

All these create an irrigation potential of 1.45 million hectares per year. Considering an annual depriciation of 3 to 4% on the total area irrigated by ground water, the actual addition in the gross area irrigated per annum is about 0.97 million hectares.

Based on the present rate of growth of about 10.5% the future ground water development in the anticipated plans is projected in the **table 4.**

Equipment needs

The large scale anticipated development of surface water and ground water shall be possible with matching supply of equipment and materials needed to develop these sources. Construction works for major and medium irrigation projects deploy heavy equipment such as buldozers, scrapers, turuopull, excavators etc. The needs, projections and programmes for ground water development are equally magnanimus, various types of equipment are required for drilling, development and construction of shallow and deep tube wells and boring of open wells. Pumps of various types and sizes, diesel engines and electric motors should also be available to match the development programme.

Tube well drilling : The programme of ground water exploitation consist of boring of open wells, and drilling of shallow and deep tube wells in different formations and at different depths. The different methods of water well drilling employed in India are:

1. Percussion (Cable tool) drilling.
2. Direct circulation rotary drilling.
3. Reverse rotary drilling.
4. Rotary air percussion drilling and
5. Core drilling.

The choice of a particular method of well drilling is essentially governed by the formation to be drilled.

Percussion drilling is achieved by rigs which are light, medium and heavy, depending on the type of the job. The hand boring sets are manually operated and the equipment comprises of a tripod, crab which, bailers, cutter shoes, anchor bolt set, loading clamp chain wrenchs, pully blocks, wire rope and other small tools **(Fig. 3).** Hand boring sets are generally used in 10, 15, 20 and 25 cm size upto a maximum depth of about 130 meters. There are several manufacturers to supply this equipment. The cost ranges from Rs.10,000 to 40,000 per set. Percussion rigs are power driven and essentially consists of a mast and two or three line hoist for operating drilling tool, sand pump and for the casing pipe. Light rigs can drill 15 cm to 25 cm diameter holes upto a depth of 100 to 130 meters. The cost of the equipment ranges from Rs.50,000 to Rs.150,000. Medium

Table 3: Annual addition of ground water works

Item	No. added per year
1 New dug wells	170,000
2 Pump sets installed on dug wells	250,000
3 Shallow tube wells	100,000
4 Deep tube wells	1,000

Table 4: Future projection of groundwater development

Plan (year)	Gross area irrigated in million hectares	Volume of water used in million hectare-metres
Triannual (1968-69)	12.90	8.15
IV (1973-74)	17.80	11.25
V (1978-79)	22.70	14.35
VI (1983-84)	27.50	17.37
VII (1988-89)	32.40	20.45

percussion rigs can drill 20 cm to 45 cm holes upto of 30 to 200 meters and the cost ranges from Rs.200,000 to Rs.450,000. Heavy percussion rigs are required for drilling deep holes in boulders or otherwise difficult formations. Manufacture of light and medium percussion rigs has been initiated by a few firms in India. Direct circulation rotary drilling is suitable for drilling deep holes in unconsolidated formations. Light direct rotary rigs have a maximum hook load capacity of about 10,000kg and are capable of drilling slim holes upto 5.5 cm drill pipes to a depth of 380 m. The cost varies from Rs. 200,000 to Rs.400,000. Medium direct rotary rigs have a maximum hook load capacity of 15 to 20,000 kgs and can drill pilot holes from 450 m to 680 m using 5.5 cm to 7.3 cm drill pipes. The cost ranges between Rs.350,000 to Rs.600,000. Heavy direct rotary rigs have a maximum load capacity from 22,500 to 45,000 kgs and can drill pilot holes upto 700 m using 8.89 cm drill pipe. The cost of the rig is Rs.10,00,000 to Rs.15,00,000. The manufacture of light and medium direct rotary rigs in India is about five to ten years old where the heavy direct rotary rigs are mostly imported at present.

Reverse circulation drilling is relatively fast in large diameter holes of 35 cm or more in soft and unconsolidated formations and is suitable for gravel pack tube wells. The cost of light and medium type reverse circulation rigs range between Rs.150,000 to Rs.250,000. The light rigs can drill 20 cm to 40 cm holes upto 100 meters in soft formations. Medium type equipment. is suitable for 45 cm hole upto 130 to 200 meters depth. These rigs are manufactured in India by two firms at present.

Rotary air percussion drilling is relatively uncommon in India. In this method the energy is applied by rotation of the bit and also through percussion impact of the bit which increases the penetration considerably. The percussion energy is applied in two ways i.e. down the hole method and above the ground method. Down the hole method can be used with direct rotary rig with modifications in the speed of the rotary table, additional compressor of 14 to 17 cm capacity and larger diameter drill pipes. The equipment for rotary air percussion drilling is imported at present.

The drilling equipment such as air operated rotary-cum-percussion rock drills with extension equipment, core drills, diamond core drills, rotary cum percussion rigs and directcum-reverse circulation rigs are also used to a limited extent for specialised jobs.

The average discharges from dug wells, shallow tube wells and deep tube wells are 5, 15 and 30 litres per second, respectively. The horse power required is 3 to 5 for dug wells, 7 to 10 for shallow tube wells and 15 to 20 for deep tube wells. Large number of manufacturers are able to meet the vast requirement of pumps, electric motors and diesel engines indigenously. With an integrated development of electric power lines in the villages, the use of electric pumping sets is increasing. Electric pumping sets are relatively easy to maintain. Diesel pumping sets in remote places face the problem of fuel supply and maintenance. There is an increasing need for the proper technical know-how and guidance in the selection, installation and maintenance of pumping sets.

Water metering

The ultimate objective of the large scale exploitation of irrigation potential is to utilize it for food and fibre production. The objective should be to achieve maximum production per unit of water used. Irrigation water has

Fig.3 A manually operated percussion drilling rig for constructing shallow tube wells.

to be used and applied most judiciously for achieving high irrigation effeciencies. Almost the entire irrigation in the country is by surface methods of irrigation. High water use efficiency can be achieved by appropriate land shaping and selection of correct irrigation stream sizes to suite the crop and soil needs. Right quantity of water is to be applied to a field in order to prevent wastage of irrigation water in deep percolation and surface runoff. Water metering devices have therefore an important role in improving the efficiency of water use. By and large, water measurement for farm irrigation is not practiced in India. The problem in tube wells is relatively simple because of a nearly constant discharge from pumping sets, thus it is easy to calculate the volume of water supplied to a field. The tube wells are generally equipped with a 90° -V notch by which the rate of water flow can be measured. The quantity of water supplied can be computed from the rate of flow thus measured and the duration of pump operation.

.The efficiency of irrigation water application in irrigation canals is relatively low. The general system is to provide fixed size outlets of pipes to allow a limited flow in the field channels. The discharge from the outlet is more or less constant in case the head of water is constant, however, in practice, there are fluctations of water head on the pipe inlet opening and the flow cannot be regulated. The measurement of water in canals is usually only at the head works of canal systems. There is a need of introducing suitable water measuring and regulation devices in canal systems.

Sprinkler irrigation : The use of sprinkler irrigation in India is only about a decade old. It is estimated that 50 to 70,000 hectares are under sprinkler irrigation. Due to relatively high cost of equipment and cheap labour the use has been limited to high value commercial crops such as tea, coffee, cardamom and orchards. Sprinkler irrigation is gaining popularity on food and fibre crops such as wheat, cotton and vegetables in areas where it is economically justifiable and technically feasible. Complete components of perforated pipes and rotating head sprinkler system are now available as they are being manufactured indigenously. Use of highly sophisticated sprinkler devices and equipment, such as automation, are yet to be introduced and their use and popularity are not expected in the near future.

Drip irrigation : Drip irrigation is the most recent method of irrigation and was originated in Israel only a decade ago and is specially successful in arid areas with poor quality water. The equipment for drip irrigation consist of a 'head' which include a pumping unit to create a pressure of about 2.5 kg/cm², a filter unit to remove the suspended impurities of water and a fertilizer tank to dissolve nitrogenous fertilizers and meter it to the supply line. The main lines are of PVC tubing, which convey water from the 'head' to the lateral lines of flexible tubing with nozzles which allow the water to flow out in small quantities, ranging from 2 to 12 litres per hour. The method is still under experimental stage for its long range effects and utility in India. Successful efforts have been made to fabricate the entire drip irrigation system indigenously at the Water Technology Centre of the Indian Agricultural Research Institute, New Delhi.

The development of surface and ground water irrigation potential is an age-old practice in India. The development of irrigation potential in the recent past in India can be matched with any advanced country in the world. With the systematic planning, irrigation will develop steadily to feed the millions of India. There is a large scale need of various irrigation equipment such as pumping sets and drilling equipment. With the development of industry, it will be possible to meet most of the equipment needs indigenously.

■ ■

Bird's Eye View of Agricultural Machinery Research and Development in India

by S.R.Verma

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Introduction

India is today a self-sufficient country in food grains. The factors that have contributed to it can be enumerated as adoption and introduction of fertilizer-responsive high yielding strains of cereals like wheat and rice along with optimum use of water, chemicals and power. The recent agricultural strategy emphasizing higher cropping intensity of the land is another important factor that has contributed to increased agricultural production in the country. It is envisaged to increase the cropping intensity to 250 to 300 per cent as compared to about 100 to 130 per cent now. Power for agricultural operations now recognized as an important factor to achieve more production per unit area has shown a rising trend in the country. The number of agricultural tractors has increased from about 11,000 in 1966-67 to about 90,000 in 1970-71(2). An estimated 50,000 wheel type, 1,500 crawler type, and 10,000 power tillers are reported to be required at present(3). Horse power per hectare available on the Indian farms, however, still compares poorly with the agriculturally advanced countries **(Fig. 1)**

Need for research and development in the field of agricultural machinery is now well recognized in the country for optimum application and efficient utilization of inputs for different crops and to ensure the timeliness in performing critical operations like seeding and planting, spraying and dusting, harvesting and threshing etc. The object of the development of agricultural machinery in India, is however, not to replace human labour but to supplement the shortage of labour in certain parts of the country and to help increase the efficiency of different operations

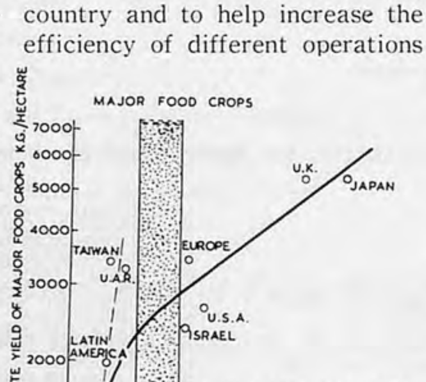

Fig.1 Relationship Between Yield and Power Input

with the use of improved agricultural equipment operated with human, animal and mechanical power.

This paper briefly reviews applied research and development work in the field of agricultural machinery in India.

Agencies for Agricultural Machinery Research and Development

Prior to 1960, agricultural machinery research and development work was confined to the Agricultural Institutes, private manufacturers and the Agricultural Departments of various states. It lacked the much needed co-ordination. With the establishment of about a dozen Agricultural Universities during the sixties in different parts of the country, the cause of agricultural machinery research and development has received an impetus. Most of these universities have full-fledged colleges of Agricultural Engineering which are well equipped to undertake research and development work. Further, the Indian Council of Agricultural Research (I.C.A.R.), besides financing several farm machinery research and development projects in these universities, made grants for the establishment of Research, Testing and Training Centres in different states. The work related with agricultural machinery research is being carried out at about half-a-dozen I.C.A.R. affliated institutes also. Private agencies, excepting five to six tractor manufacturers and about half-a-dozen others, manufacturing diesel engines and irrigation pumps have hardly any organization to carry out research and development work. There are, however, about 1300 small scale industries engaged in the manufacture of agricultural equipment in the country at present(2). These manufacturers, therefore, depend on the aforementioned agencies for the development of suitable products for their survival. Some of these industries, however, have made good innovations in the field of agricultural machinery under the guidance of the agricultural engineers, scientists and farmers.

Agricultural Machinery Research and Development

Table 1. presents the size of holdings in India which vary widely(2).

Table 1: Operational Farm Holding in India

	Holding size (hectares)	% age of households	% age of area cultivated
Small	Under 4	86	36
Medium	4 to 10	10	29
Large	Over 10	4	35
	Total	100	100

According to holding size, **table 2** presents the status of tractor ownership. There are only about 4% farmers who own tractors in the size holding groups of less than 10 hectares(1). Human and animal power, therefore, continue to be the important source of power for the farmers owning less than 10 hectares. Majority of tractors are owned by the farmers owing more than 10 hectares of land and tractor operated machinery is also required by them. The existing equipment and research underway in the country is being briefly reviewed here.

Table 2 : Tractor Ownership According to Holding Size

Holding hectares size	Percentage of tractor owners
Less than 10	4
10 to 40	53
Above 40	43
Total	100

Equipment for Land Shaping and Seed-bed Preparation

Bullock and tractor operated land levellers, land planes, buck scrapers, floats, bund formers and ridgers are available in different areas in the country now.

Animal drawn and tractor operated mould board plows, tractor operated disc plows, and disc harrows are now being manufactured by more than two dozen industries in the country. Scarcity of proper grade of steel for the manufacturing of soil working components like plow shares, cultivating shovels and discs continue to be a bottleneck for this category of equipment. The Indian Standards Institution is engaged in preparing suitable standards for tillage equipment especially the fast wearing components like shovels, shares, discs etc.

In the rice growing areas, tractor and animal operated puddlers have been evolved and are being manufactured by a few agencies in the country. Tractor mounted single action disc harrows with cutout blades are also used for puddling. Studies on the quality of puddle and equipment for puddling have been conducted at some places.

Research on soil-tillage dynamics and traction has been initiated at some of the institutions. Work on measurement of draft requirement tillage equipment as well as on techniques to develop quantitative measurement of the parameters governing the soil behaviour and contributing to better plant germination and growth is, also, underway in some institutions. Recently projects on energy requirements for tillage and other operations have also been launched in the country.

Power tillers have been introduced in a limited number in the rice growing areas of the country during last 6 to 8 years. Much progress in the direction of rotary tillage has, however, not been made so far. Performance studies on the rotavator and spade plows as used in Neitherland, Germany and Japan are now being planned in some institutions. Manufacture of tractor operated rotavators based on the imported designs, has also been started by a few manufacturers.

Over 75 per cent of the cultivated area in the country is still unirrigated. Research and development of the agricultural machinery for the dry farming regions is, therefore, a very important area for work. Chisel plows, sweep cultivators, oscilliating bar harrows etc. are being developed and studied at several research stations under the dry farming schemes initiated by the I.C.A.R.

Seeding and Planting Equipment

Major emphasis in this area during the last one decade has been on the research and development of animal and tractor operated seed-cum-fertilizer drills **(Fig. 2)**. Planters with fertilizer attachment have also been developed for row crops like maize, cotton, groundnut etc. There are now about two dozen manufacturers of the seeding and planting equipment in the country. The tractor operated equipments are invariably of the mounted type.

These machines have provision for the placement of the fertilizer about 5 cm to the side and about 5 cm below the seed. Studies conducted by the agricultural engineers and agronomists have revealed that the use of a seed-cum-fertilizer drill results in 15 to 20 per cent increase in the yield of crops. The Indian Standards Institution has undertaken the work of standardisation of important components of the seed drills.

The current research and development work in the field of seeding and planting is being persued to develop multi-crop machines to cut down the investment at the farmers level. Development and incorporation of positive feed devices for fertilizer metering is an important aspect under study. The matching of the equipment with the source of power is likely to lead to the development of semi-mounted machines in the near future. Development of suitable types of furrow openers for different soils and crop conditions is also being pursued by several researchers. Studies are being conducted on compaction in relation to seedling emergence and plant growth. The seeding equipment are also being modified for dry farming areas.

For the rice growing areas a paddy transplanter is badly needed. The operation is carried out manually at present. After attaining self-sufficiency in wheat production in the country, emphasis is now being placed on rice production as it is the staple food of a large number of people in India. Extensive trials of Japanese transplanters will be needed to make a beginning with the mechanical transplanting of paddy.

Mechanical planting of potato and sugarcane has been a subject of study at some institutions during last few years. The trend is towards two-row tractor operated machines of semi-automatic and automatic types **(Fig. 3)**.

Work on rationalisation of cultural practices for seeding and planting along with needed machine modifications, has also been initiated.

Fig.4 A 1.8 metre Cutter bar Tractor Front Mounted Punjab Agr. University, Ludhiana for Wheat

Equipment for Fertilizer Application

Fertilizer spreaders have not made much headway so far. Availability of some commercial fertilizers like superphosphate in the powder form and their hygroscopicity have posed major problems with their metering and uneven application. Use of gravity feed metering devices with agitators is common on the fertilizer-drills in India. Revolving bottom metering device has been used on the unit-planters. Development of fertilizer applicators for standing crops and puddled soils stands recognised as an area for research and development. Use of anhydrous or aqua-ammonia has not made any headway in India so far as these are not being commercially produced. Some studies, however, have been made in this direction.

Post Sowing Operations

Manufacture of cultivators with sweeps and shovels has been initiated by some manufacturers recently. Tractor front-mounted and mid-mounted cultivating units are considered useful but have not been developed so far. Rationalising and modifying cultural practices and planting geo-

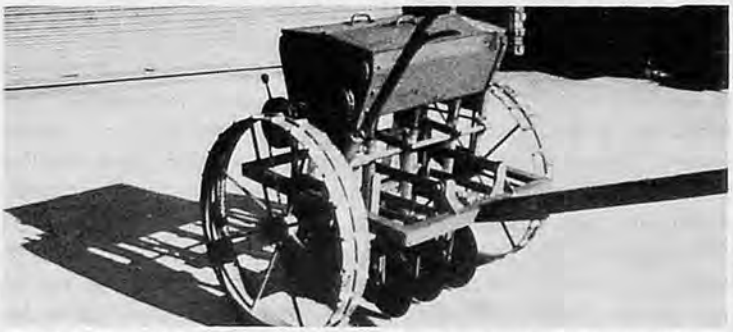

Fig.2 A Typical 3-Row Bullock Drawn Seed-cum-Fertili er Drill for Sowing Wheat, Barley, Gram, Peas etc.

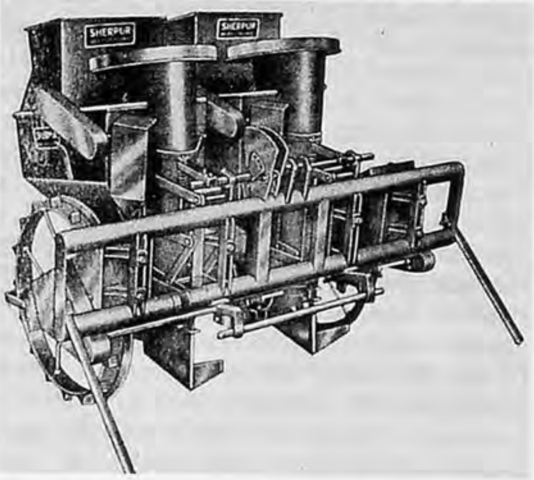

Fig.3 A Tractor Mounted two-row Potato Planter Now Being manufactured by a Firm in Punjab

Reaper Windrower Developed at The Harvesting

metry for mechanising post-sowing operations for crops like groundnut, maize and cotton is now a subject of study.

Herbicides like 2-4D, gramoxone etc. are now being introduced for chemical weed control by some companies in the country. Appropriate modifications in the spraying equipment are being made for their application. Afairly wide range of hand and power operated sprayers including power operated knap-sack type and tractor mounted p.t.o. operated sprayers are now available for pesticide application. High speed petrol engines of 1.7 to 2 h.p. weighting about 8kg. are also being manufactured. Development of proper type of nozzles and restrictors for ultra-low volume (ULV) application of pesticides is being pursued. High pressure, low volume orchard sprayers for spraying the fruit trees like mangoes, litchies, apples etc. will have to be developed. Introduction of the Japanese type 'Speed sprayers' holds good promise.

Research on electro-static changing of spray particles has been carried out at some institutions. Commercial equipments have, however, not been developed so far. Self-propelled high clearance sprayers await development. Aerial spraying of cotton has been initiated in some areas. Research work on aerial spraying, however, is yet to be initiated.

Harvesting

Harvesting of cereals like wheat and paddy has become a critical operation due to inadequate labour availability. The operation needs to be carried out promptly to prevent field losses of grain as well as to prepare the seed-bed for the succeeding crop. Prototypes of animal and tractor operated reapers for wheat harvesting have been developed and their manufacturing has been initiated by few firms. Similarly, for root crops like groundnut and potato, prototypes of animal and tractor operated diggers have been developed and are now being taken up for commercial production. **Figures 4 to 6** show prototypes of wheat, groundnut and potato equipment developed in the Department of Agricultural Engineering, Punjab Agricultural University, Ludhiana.

Combines for wheat and paddy harvesting have also been introduced during last few years in the more mechanized states of India. There are at present about 100 imported self-propelled combines of 3.5 to 4 meter cutter bar and about 200 tractor side-mounted Vicon combines of 1.5 meter cutter bar **(Fig. 7)**. The latter is being manufactured in India with foreign collaboration. Whereas the tractor operated combines are owned by the peasants directly, the large size machines have been imported by the private and government agencies and are being operated on custom-hire basis. During wheat harvest season of 1971 about 16,000 hectares of wheat crop out of a total of about 18.4 lakh hectares were harvested by these combines in the state of Punjab.

Research on the development of various types of harvesting machines and their evaluation under varying crop and field conditions is being pursued by several agencies. Imported equipment for harvesting wheat, paddy,

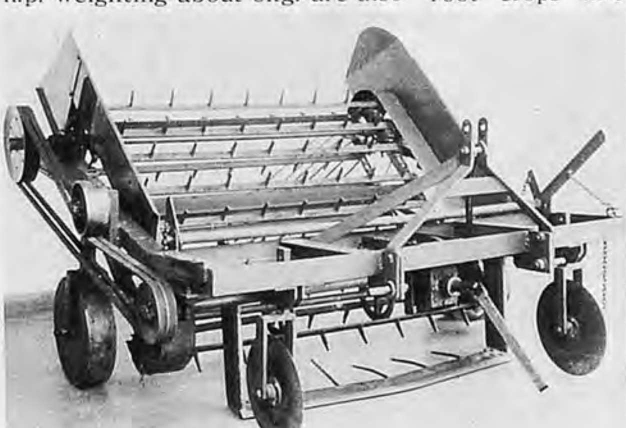

Fig.5 A Tractor Rear Mounted Groundnut Digger Shaker Windrower Modified and developed at the Punjab Agr. University, Ludhiana

Fig.6 A Single Row Potato Elevator Digger Developed at The P. A. U. Ludhiana

maize, groundnut, potato and cotton suitable for Indian conditions hold good promise.

Threshing

Introduction of stationary threshers for wheat will go down as a remarkable event in the history of Indian Farm Mechanization. These threshers operated with prime-movers of 5 to 40 h.p. are unique in their design in as much as they not only thresh the grain but also bruise the straw fine to utilize it subsequently as a cattle feed. An estimated 150,000 of these threshers are now in use. The capacity of these machines varies from 40 to 50 kg. of clean grain per horse power-hour. Owing to increase in food grain production the demand for high capacity threshers capable of threshing the crop at about 15% grain moisture content has increased during last one year or so. Development of high output stationary threshers with low energy requirement per unit of grain threshed has been initiated at several institutions and prototypes of straw rack and axial-type threshers are now being developed.

Use of power operated stationary threshers for paddy is quite nominal at present. Japanese-type pedal and power operated paddy threshers of the head feeding type are being manufactured by one or two companies. Further development is in progress.

Hand and power operated maize shellers operated with 5 to 7.5 h.p. motors are now widely manufactured in India. These are based on imported as well as indigenous designs.

Research and development on mechanical threshing of crops like groundnut, soyabeen and sorghum etc. is also underway in different parts of the country.

Miscellaneous Equipment and Research Areas

Among other worth mentioning equipment being manufactured in the country include oscillating screen-type grain cleaner-cum-graders, crop driers, hand and power operated chaff-cutters, silage cutters, trailers etc. Research on the development of sizers for root crops and fruits is also in progress and prototypes have been developed. Research on human engineering, safety and other ergonomical aspects like vibration and noise is now being recognised as an important area of agricultural machinery.

Conclusions

The research and development in agricultural machinery in India has been briefly reviewed. Bird's eye-view of the manufacture of the various equipment has also been attempted. For each category of equipment, the scope for further development and improvisation is unlimited.

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Fig.7 Tractor Side-Mounted Vicon Combine with 1.5 Metre Cutter Mumber about 200 in Northern India. These are Being Manufactured in India

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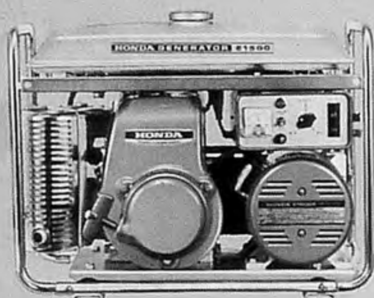

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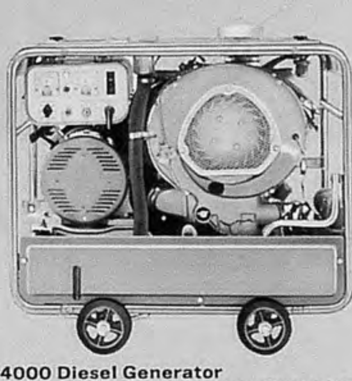
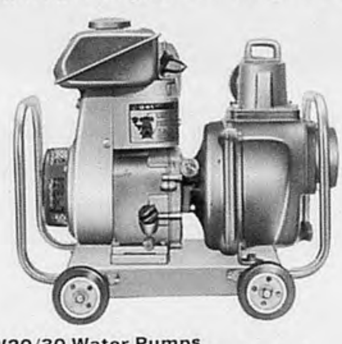


E4000 Diesel Generator
10hp diesel engine. 120-240V 4000W AC and 12/14V 100/200W DC. Weight: 183kg.

E300 Portable Generator
1.1hp gasoline engine. 117-240V 250/300W AC and 12V 70/100W DC. Weight: 18.2kg.

E800 Portable Generator
2.8hp gasoline engine. 120-240V 800W AC and 12V 100/120W DC. Weight: 35kg.

EC1500/EG1500 Portable Generators
4.5hp gasoline engine. 120-240V 1500W AC. Weight: 37kg (EC1500): 40kg (EG1500).



W20/30 Water Pumps
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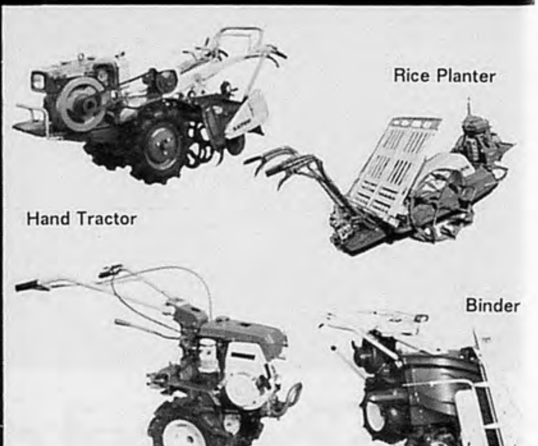

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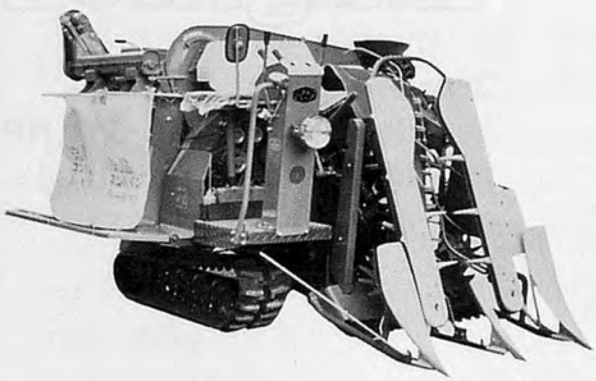

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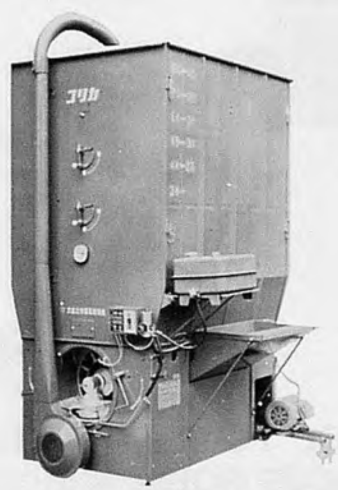

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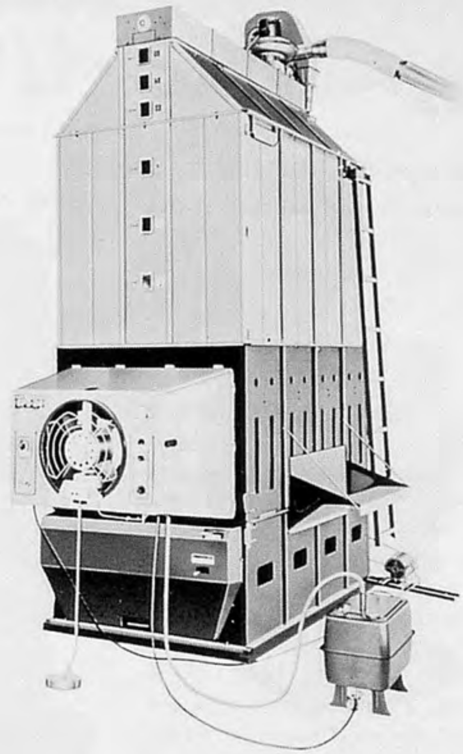

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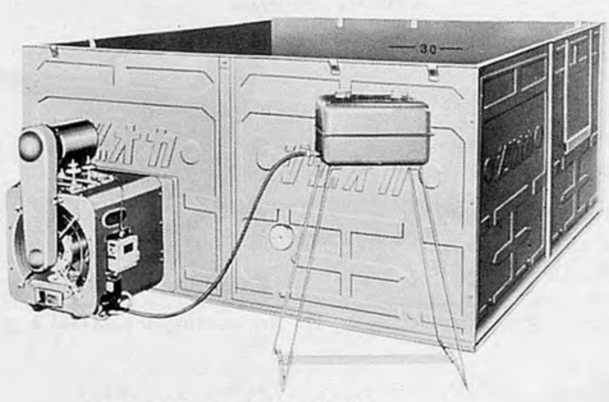

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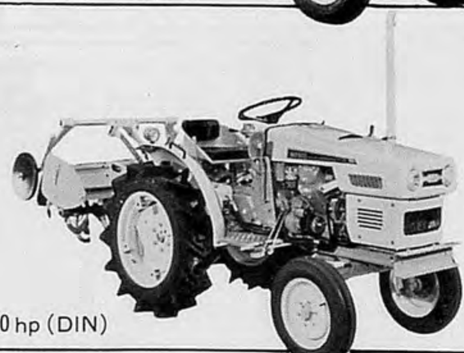

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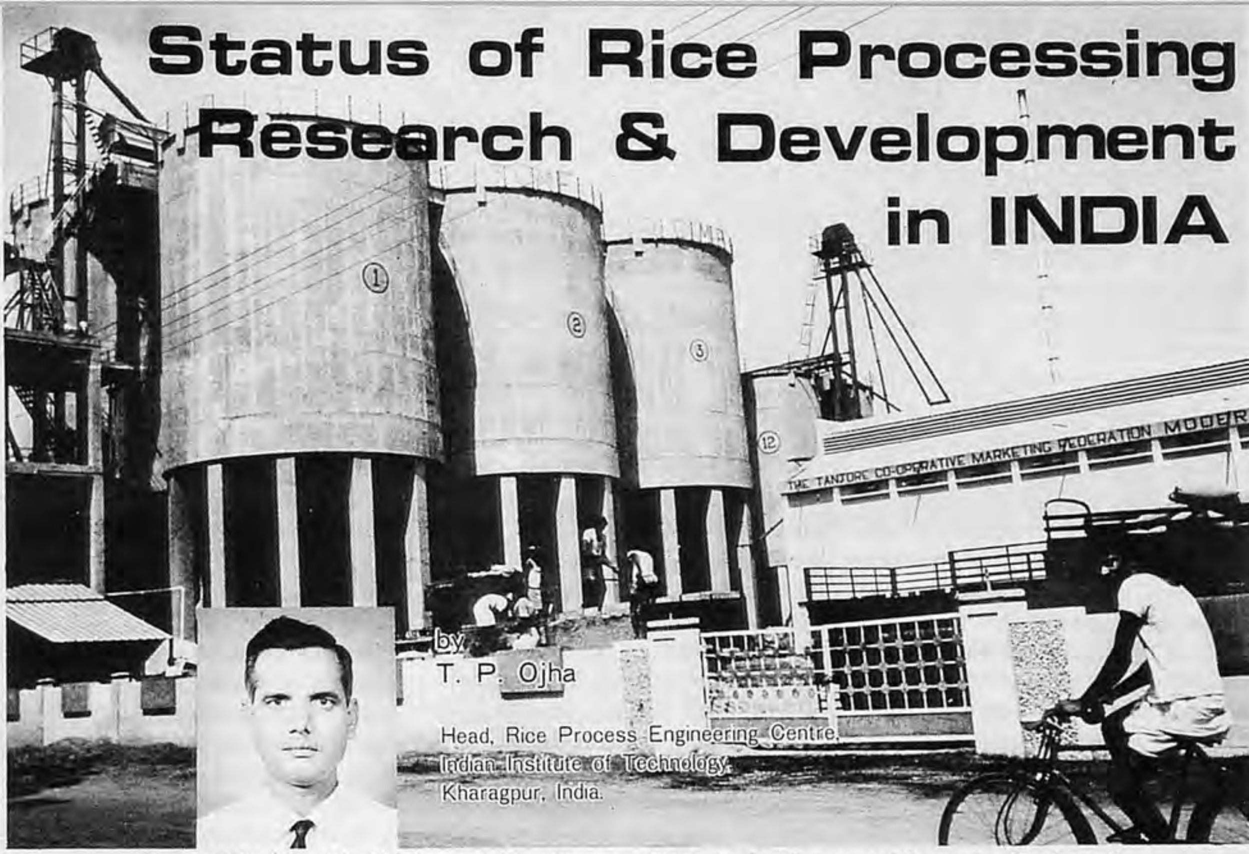
Status of Rice Processing Research & Development in INDIA



by
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(New 4TPH Rice Mill, Building and Silo Storage with Mechanical Dryers and Conveying Equipment)

Paddy is the most important cereal crop in India. About 37 million hectares out of 157 million hectares of cropped area is under paddy crop each year. Total paddy production in the year 1971 was nearly 64 million tonnes. Thus the total value of the paddy crop was approximately Rs. 40,000 million. This amount accounts for nearly 40% of the tatol value of the food grains produced in India. However, the requirement of paddy for India is estimated at about 80 million tonnes. While making efforts to increase paddy production, we have to ensure maximum outturn of rice therefrom coupled with full utilisation of the by-products and elimination of avoidable wastes. It is generally estimated that in India 10% (6.4 million tonnes) of total paddy produced is usually lost in the various operations such as harvesting, drying, milling, handling and storage. It is also estimated that the rice outturn can be increased by about 7% with improved technique of drying, parboiling and milling.

Historical background of Rice Processing Industry

Most of the paddy is processed by indigenous rice hullers in India. There were about 45,827 hullers, 4,244 sheller hullers and 2121 shellers in use during 1968 in India. The number of modern rice mills employing rubber rolls were very few in use by that year. The seven modern rice mills (Table 1) were installed on the recommendation of an expert team of Ford Foundation which visited India in 1963. The expert committee had recommended that by adopting improved techniques of parboiling, drying, milling and storage, outturn of rice could be considerably improved. These mills were imported and installed as evaluation and demonstration units. The first rice mill along with the mechanical dryers, conveying equipments, paddy cleaners, and storage silos was installed and constructed in 1965. Paddy is received at the plant in trucks and bullock carts from the paddy collecting centres. The paddy is tested for moisture content, foreign material content and milling quality, before it is mechanically conveyed to the cleaning and drying sections. The drying equipment consists of Lousiana State University (LSU) type continuous flow dryers, and tempering bins. Paddy is received from the collecting centres, ranging between 16 and 22% moisture content wet basis (w. b.). Usually, 3 to 4 passes of 30 minutes duration are required to bring down the moisture content from 22% to 14% level. Between two passes a tempering time of 6 to 8 hours is provided to equalise the moisture in the paddy grain. Most of the dryers installed in India are 6 or 12 tonne holding capacity. Mostly 85°C hot air directly or indirectly heated by burning furnace oil is used for drying paddy. While drying parboiled paddy in LSU type dryers, the air temperature is raised to about 95°C for the inital drying when the moisture content of the paddy is about 35%.

In the process of mordernising the rice milling industry, it was felt necessary to establish drying and storage facilities at many places in the paddy production areas and such places are called the 'Paddy Drying Centres'. Such 30 centres were organised in one district of South India during 1966-67. Each centre consists of (1) dump pit for unloading bagged paddy; (2) two 25 tonne per hour capacity elevators; (3) two 6 tonne LSU dryers with heat exchangers; (4) two 200 tonne metal silos, (5) one godown of approximately 200 tonne capacity. (6) one each of weigh bridge, and grain moisture metre.

While establishing these centres, as well as the rice mill units, industries faced many problems in design, construction and operation. The shortage of trained engineers and technicians to run and maintain the modern rice mills and other equipments was a serious problem. In 1966, another team of Ford Foundation experts after having visited the working of the modern rice mills, made recommendation for organising research and training programme in rice processing in India. The Government of India (GOI) appointed a committee under the Chairmanship of Mr.K. T. Chandy to survey and recommend suitable location for establishing a research-cum-training centre for rice processing in India. The committee recommended that such a Centre be established at the Indian Institute of Technology, Kharagpur. Some of the important events with regard to the rice processing in India took place in the following chronological orders:

1. In July 1966, a Ford Foundation Consultant in rice processing was appointed for full time assistance to the rice industry.

2. In January 1967, the Ministry of Food, GOI deputed 5 engineers to Lousiana State University (LSU), U.S.A. for higher training and research for a period of two years.

3. In the year 1968, a team of experts from Central Food Technological Research Institute (CFTRI), and other Institutes conducted the evaluation of all the modern rice mills. Their results are presented in Table 2.

4. The first short term training course of 3 months duration for the rice mill engineers was conducted in October - December 1968 - at IIT, Kharagpur.

5. A seminar on modernisation of rice industry was organised by the Indian Institute of Management, Ahmedabad, in January 1969 at Bangalore.

6. Based on the recommendation of the Chandy Committee, the Rice Process Engineering Centre (RPEC) was established in February, 1970 at the IIT, Kharagpur. The GOI is meeting rupee component of the expenditure and Ford Foundation is supporting with the dollar founds.

7. The first batch of students for Master of Technology in Crop Process Engineering were admitted in August, 1970. They will complete their programme of study and research by the end of July, 1972.

8. UNIDO and Food Department of GOI organised an interregional seiminar on "Industrial Rice Processing" in the months of October, 1971 at Madras.

9. The first Rice mill managers' training course of 3 weeks duration was conducted during April-May, 1972 at the RPEC, IIT, Kharagpur.

Objectives of RPEC at IIT, Kharagpur

The main objectives of the Centre are :

i) to offer postgraduate education in Crop Process Engineering;

ii) to conduct research on all aspects of paddy processing;

iii) to organise short term training courses for rice mill managers, engineers, and Operators of India and abroad;

iv) to collaborate with rice industry and other research organisations and universities.

The RPEC is in a position to provide facilities for the training in modern rice processing technology to nationals of other Asian nations. During the last two years, number of short term courses were organised and few large scale field trials on some aspect of post harvest technology of paddy were conducted with considerable success.

The present M. Tech course in Crop Process Engineering of 2-year duration has the admission capacity of 10 students per year. However, the strength can be increased depending upon the requirements to admit participants

Table-2. Comparative performance of various types of rice milling units.

Type of paddy	Type of machine: Huller	Under run disc sheller	Modern mill
	% Outturn from paddy		
Parboiled	X	(X +0.8)	(X +1.6)
Raw	x	(x +2.5)	(x +6.6)
	% Head yield from paddy		
Parboiled	Y	(Y +2.8)	(Y+4.1)
Raw	y	(y +9)	(y +15)

where X = 64-68%, x = 60-64%
Y = 60-62%, y = 35-40%

The numerical figures quoted in the above table are the average values.

Table-1. Modern Rice Mills for Evaluation and Demonstration.

Sl. No.	Location	Make	Capacity (Tonne/hr)	Remarks
1	Thiruvarur Thanjavur(Tamil Nadu)	Schule	4	Cooperative undertaking
2	Mandya(Mysore)	Satake	2	— do —
3	Tadepalligudem, West Godavari(AP)	Satake	4	— do —
4	Raipur(M.P.)	Schule	2	— do —
5	Bargarh, Sambalpur (Orissa)	EGDR	1	— do —
6	Memari, Burdwan (W.B.)	Satake	2	— do —
7	Bikramganj, Shahabad(Bihar)	Kyowa	4	Public sector undertaking

from other Asian countries. The curriculum includes the study of Heat and Mass Transfer, Advanced Mathematics, Industrial Engineering, and also the study of advanced topics on Crop Process equipment design, installation, operation and maintenance; Drying, Milling, Storage, Rice Technology; Systems Engineering; Mechanical Handling of equipment, etc. After completing 9 months of course work, the students have to work for 3 months for industrial training. During the second year, the students conduct investigation on problems related to rice processing in the laboratories of RPEC or at a modern rice processing plant.

The RPEC has been organising a short term course once a year of the following types :

i) Rice Mill Engineers' course of 3 months duration;

ii) Rice Mill Managers' course of 3 weeks duration;

iii) Rice Mill Operators' course of 2 weeks duration.

A new certificate course of one year duration is being proposed to be offered to the workers holding degree in Science, Engineering or Technology from August, 1973.

Research Work done or in progress

Research work on rice technology has been under way at the Central Food Technological Research Institute (CFTRI), Mysore and at Jadavpur University, Calcutta, since long. Both of these Institutes have carried out good work as far as the parboiling process and equipment design are concerned. However, a systematic and all round study on post harvest technology of paddy was not adequately undertaken by any of these Institutions in India. It was at I IT, Kharagpur the research work on paddy/rice processing was started in 1965. The

Modern Paddy Drying Center

research work as listed in the following pages, are available either in the form of a thesis or a report at the Agricultural Engineering Department, and RPEC, I IT, Kharagpur.

A. Properties of paddy grain :

i) Measurement of thermal properties of paddy grain and its by-products (1968),

ii) Evaluation of some physical, thermal and milling properties of paddy grains (1968),

iii) Physical properties of paddy grain (1970),

iv) Dielectric properties of paddy grains(1971).

B. Paddy harvesting and Threshing :

i) Harvesting and threshing of paddy (1965).

ii) Productivity studies on harvesting and threshing of paddy and testing of Kubota paddy thresher (1966),

iii) Field studies of harvesting paddy at different moisture contents and its affect on various losses and milling quality (1971).

C. Drying :

i) Drying characteristics of paddy with forced ventilation (1967),

ii) Determination of constants C and n used in the Henderson's equation on equilibrium moisture content of paddy varieties (1969),

iii) Design, construction and testing of farm batch dryer (1969),

iv) Temperatures, passes, tempering time and total drying time for some common varieties of paddy (1970),

v) Design, development and performance of a batch dryer for paddy (1970),

vi) Development of a recirculatory batch dryer (1971),

vii) Drying characteristics of paddy with LSU type model dryer (1971),

viii) Field and laboratory studies on recirculatory batch dryers (1972),

ix) Use of Infrared energy for paddy drying (in progress),

x) Drying of parboiled paddy (in progress).

D. Milling:

i) Machine requirements for milling of paddy (1965),

ii) Design and development of triple rubber roll sheller (1967),

iii) Design and development of paddy cleaner and separator (1968),

iv) Testing of small size indigenous rice processing machines (1970),

v) Performance of paddy cleaner and sheller (1971),

vi) Effect of drying temperature and time on milling quality of rice (1971).

E. Storage:

i) Measurements of temperature and moisture contents of stored paddy (1967),

ii) Aeration of stored paddy (1969),

iii) Temperature and moisture variation in bulk storage of paddy (1968),

iv) Storage of paddy with and without aeration (1970).

F. Instrumentation :

i) Calibration of moisture metres (1970-71),

ii) Development of a rice polish metre (1970),

iii) Development of polish

measuring device (in progress).

G. Parboiling :

i) Parboiling of paddy (in progress),

ii) Design and Development of parboiling system in cement tanks (in progress).

H. Testing and Evaluation :

i) Evaluation of indigenous rubber rolls (in progress),

ii) Testing of rice processing equipment such as paddy dehusker, polisher, etc. (in progress),

iii) Testing and milling qualities of newly evolved paddy varieties (140 varieties already tested and tests are in progress in the Rice Grading lab.),

iv) Testing of Satake paddy separator (in progress),

v) Testing of Satake rice polisher (in progress),

vi) Testing of Satake paddy cleaner (in progress).

I. By-product Utilisation :

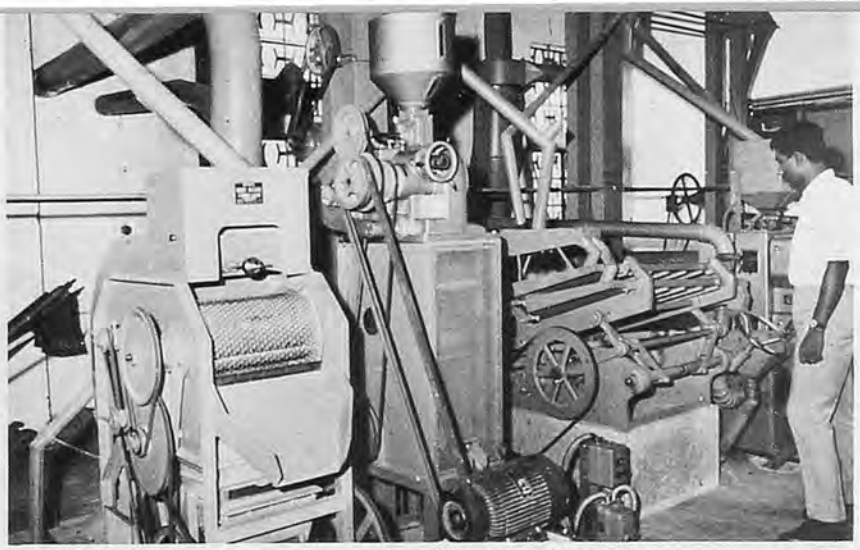
i) Use of paddy husk as a fuel in rice processing plant (in progress),

ii) Use of paddy husk as a insulation (in progress),

iii) Stabilisation of rice bran (in progress).

Present status of Rice Processing in India

Rice processing as a whole has progressed rapidly during the last five years (1968-72) in India. Most of the rice mill owners have been seriously thinking to modernise their rice mills before very long. In general, they are not convinced to use the mechanical dryers (LSU type dryer) and improved parboiling tanks (CFTRI parboiling tanks). They do not want to discontinue open yard sun drying of paddy. However, they feel that the indigenous paddy hullers must be replaced by the modern rice mill plants. The act passed by GOI in 1970 enforcing partial or full modernisation of rice milling industry has worked as catalyst in achieving the progress. By the May 1972, about 200 modern rice mills were commissioned. There are organisations like National Cooperative Development Corporation (NCDC) and many commercial banks which are prepared to offer loans to the millers to modernise their existing rice mills. NCDC has financed the establishment of 780 paddy processing plants out of which 41 are modern rice mills in cooperative sector.



Interior View of Rice Mill at I I T Kharagpur

Many cooperative rice mills in different states of India are not being utilised to their full capacity due to which they are perhaps not running economically. The under-utilisation of rice mills is mainly due to the paddy/rice procurement policies of the states. The levy system impressed by the Government affects adversely the cooperative rice mills.

The Food Corporation of India (FCI) has installed 18 modern rice mills in different states of India. There are about 60 modern rice mills in the state of West Bengal alone under private sector. The main problem facing these rice millers and industry is lack of technical know-how with regard to rice processing technology. Many of the rice millers in the Eastern India have modernised their mill by replacing hullers with the rubber roll shellers. Some of them have added modern parboiling equipments also. A few of them have realised the importance of potentiality of bran oil industry and are planning to start bran oil extraction soon. It is estimated that about 40 million tonnes of rice at 4% polish gives 1.6 million tonnes of bran which may yield about 320,000 tonnes of bran oil per year if the oil is properly extracted.

Conclusion

The results obtained from the seven modern rice mill units have amply demonstrated that benefit of modernisation could be extended further. The present number of 200 modern rice mills in India is perhaps due to that. It is hoped that the experience gained and success achieved in the process of modernisation can be shared with other South East Asian countries. The training and research facilities available at the RPEC,I IT, Kharagpur, India, are open to the industry and research organisation to take advantage of.

■ ■

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2. Rama Rao, V.V. and Pandya, A.C. ··· *Rice Processing in India* ··· Paper presented at the Rice Mill Managers' Training Course, May, 1972, IIT, Kharagpur.
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Applicability of Japanese Agr'l Development to the Developing Countries, specially BANGLADESH

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(**Abstract** : In the course of my studies on the solutions to the problems confronting the developing nations, I found that Japanese agricultural, industrial, and economic practices are, if wisely adapted, suitable to all the developing nations, specially to those with little or no natural resources. The reason why the developing nations can not adapt these practices is the lack of analysis of Japanese systems from all minute perspective. Introduction of advanced technology and facilities is the vital element of the solution, but creation of base to absorb technology is the prerequisite to the effective introduction of technology. Again, even if technology is available, modernization and industrialization is not possible unless the income level of the majority of the people, specially, the farmers is raised. All these problems and solutions thereto will be the subject matters of my book, "The Approaches to National Economic & Industrial Planning for The Developing Countries, Particularly Bangladesh —— with Special Reference to the Development Process of Japan "which is going to be published very soon. This article is the agricultural portion of the above book. All the developing nations are expected to find some elements of interest in the analysis and recommendations made here for planning their development policies and systems. This article however starts with the analysis of Japanese agricultural practices and evolution.)

Before Meiji period started in 1869, no Western economists or even the historians could think that Japan with all the criteria of a poor nation might someday emerge as an economic power in the world. But Japan as a developed country is now a reality proving that any people however poor, at one time, they may be, can build their nation as they want if the people collectively work for it. Japan's development rate was high because her approaches was correct and their implementation was faithful.

The central force which prompted a radical change in the time-old system of Japan was the realization by the Emperor Meiji that the difference between his poor nation and the then developed countries lay in science and technology only.

The sole aim of the Meiji period was to introduce in Japan science and technology from Europe and America and thus build for themselves a nation at least of European level.

Thus any analysis of Japan's economy will merely be an analysis of how effectively and how quickly she could import and assimilate advanced technology from abroad to increase her productivity. Unlike many developing countries, Japanese leaders never attempted to import bulk of consumer goods to improve the standard of living of her people; because she rightly knew that it would be impossible to uniformly enhance the standard of living of the entire people with imported goods while they did not have much natural resource to pay for those. They went by the conviction that they should build their country themselves, and no other nation could or would build Japan. This realization is still intact with Japan. As a matter of self-realized policy, Japan is maintaining a safe margin between increase in productivity and the raise in wage

Table 1. Induction of Foreign Technologies & Investment in Japan

(January, 1950-August, 1971) (based on U.S.$1 = 360 yen)

Technologies

	Cases
Textiles	447
Chemical products	1,442
Chemical fibers	33
Pharmaceutical & agricultural chemicals	261
Organic industrial chemicals	628
Inorganic industrial chemicals	197
Others	321
Petroleum products	175
Glass, stone & clay	212
Metals & metal products	282
Iron & steel and non-ferrous metals	443
Machinery	4,349
Electric machinery	1,613
Power transmission & distribution etc.	250
Household appliance & lighting equipment	96
Communication machines	580
Electronic machines	181
Others	506
Transport machinery	497
Precision machines	228
Non-electric machinery	2,511
Prime movers	143
Metal working machines	259
Textile machines	162
Agriculture, construction & mining machines	145
Other industrial machines	1,507
Others	295
Food & tobacoo	108
Plastic products	432
Other products	460
Construction	82
Others	46
Grand total	3,983

Investments

	Cases	Value (¥ million)
Acquisition of stock & proprietary interest	400,256	2,545,320
Through stock markets	390,241	2,170,064
Participation in management	1,964	232,754
Others	77,031	134,002
Beneficiary certificates	7,139	3,749
Debentures	1,324	68,669
Claimable assets arising from loans	2,436	2,561,592
External bonds issued	79	464,401
Foreign enterprises' investment to their Japanese branches etc.	3,760	96,084

(Source : Industrial Review of Japan '72)

Table 2. Important Farm Equipment in Use, Labor hr, and Yield of rice(paddy) in Japan (1 ha =2.47 acre) Unit : 1000

	Motor	Engine	Power thresher	Huller	Power tiller	Preventive machine	Riding tractor	total labor. hr per ha of rice	yield per ha paddy 1000 Kg.
1920	1	2	—	—	—	—	—	(size of	
1923	2	9	—	—	—	—	—	the plant-	
1925	5	25	—	—	—	—	—	ed area	
1927	12	39	30	39	—	—	—	is taken	
1931	28	64	56	77	0.1	—	—	to be	
1933	38	81	67	95	0.1	0.4	—	0.5~	
1935	47	96	92	105	0.2	1	—	1.0	
1937	66	121	129	108	1	2	—	ha.)	
1939	91	202	211	133	3	5	—		3.20
1942	145	317	357	180	7	—	—		
1945	152	263	352	177	—	—	—		
1947	287	229	444	199	8	7	—		3.05
1949	538	345	764	348	10	11	—		3.20
1951	620	383	972	—	16	20	—		3.30
1953	870	642	1,269	540	35	44	—		
1955	956	1,134	2,038	690	89	87	—		4.34
1957	1,034	1,601	2,283	—	227	155	—	1955	
1959	1,124	1,696	2,459	800	514	305	—		
1961	1,152	1,673	2,703	—	1,020	361	7	1828	
1962	—	—	2,832	—	1,414	436	11	1612	
1963	1,163	1,721	2,982	—	1,812	565	—		
1964	1,366	1,903	3,085	827	2,183	704	24.8	1549	
1965	—	1,801	3,048	—	2,490	851	—	1479	
1966	—	—	—	—	2,725	1,126	38.5	1475	4.53
1967	1,381	1,727	3,297	1,008	2,971	2,091	57.9		5.75
1968	—	—	—	—	3,030	1,939	124.3		5.72
1970	—	—	—	—	3,159	2,171	—		
1971	—	—	—	—	3,197	2,415	278.0		

Source : 1972 Farm Machinery Statistics by Farm Machinery Industrial Research Corp. Tokyo.
Changes and Mechanization in Agriculture in Japan by Tsutomu Mukumoto.

—— challanging the entire world in price competition. These facts coupled with other factors behind Japan's economy described in section 2, made her progress natural and balanced.

Japan's Economic Take-off and Agriculture

The economic growth does not mean growth in one particular field only, it should always mean a growth in diversified fields. The growth pattern of some fields are given separately in the subsequent parts of this section. The preparation period for take-off had the following features.

(1) Introduction of compulsory education (1872)
(2) Introduction of advanced science and technology from Europe and the U.S.A. (Refer to **table 1**)
  a. by inviting foreign teachers, engineers and scientists.
  b. by purchase of special study reports.
  c. by importing industrial facilities and know-how.
  d. by license agreement and purchase of patent right.
  e. by training Japanese in advanced countries.
(3) Dependence on mainly internal resource.
(4) High rate of savings.

Overall Economic Growth is the result of individual growth in a number of fields. The initial selection of industries in Japan

Figure 1. History of Farm Machinery Production in Japan

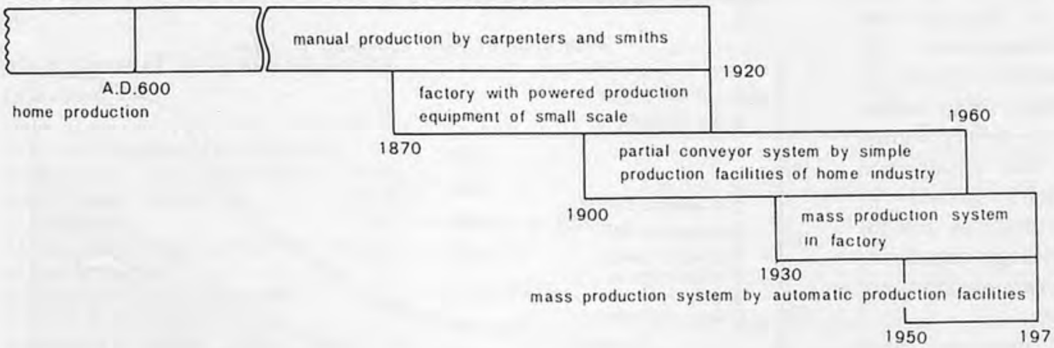
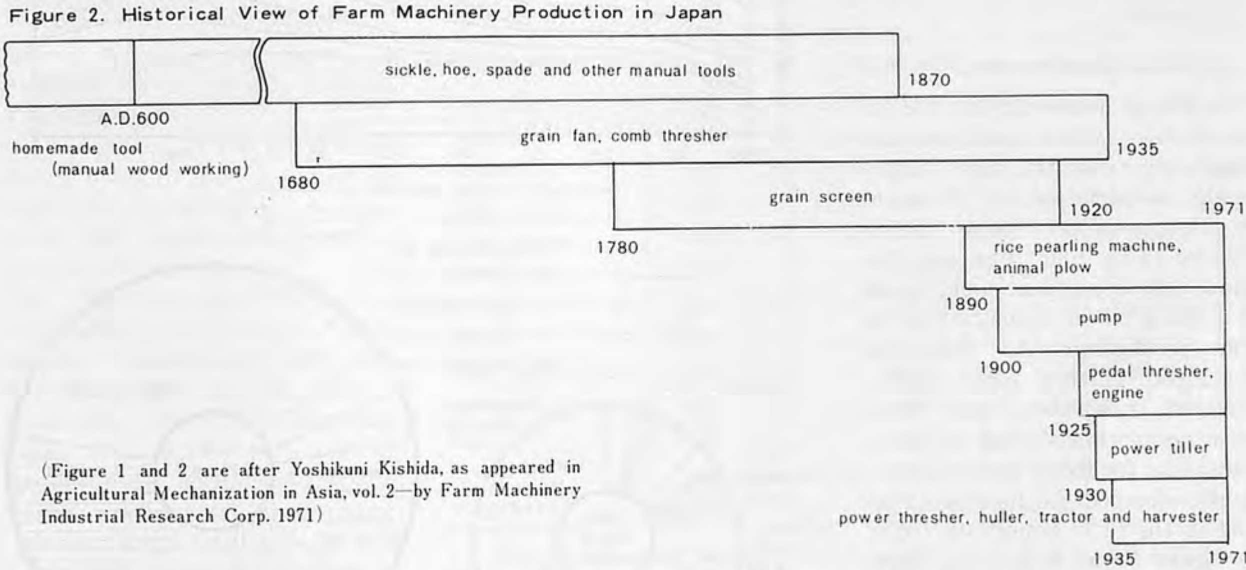


Figure 2. Historical View of Farm Machinery Production in Japan



(Figure 1 and 2 are after Yoshikuni Kishida, as appeared in Agricultural Mechanization in Asia, vol. 2—by Farm Machinery Industrial Research Corp. 1971)

was on the basis of common "maximum value adding industries, first". (some people may argue that there was no unified planning in Japan; it may partly be correct but the cooperation between the people are so common and extensive that things done at private levels produce results of highly coordinated plans). As it will not be possible to explain here in details all fields of economic interest, only a few major fields will be described.

In early period of development, Japan was not in a position to import its necessary food grain —— mainly rice, nor could she expand her cultivable area. So she had to resort to the development of agricultural technology to increase her land productivity. Extensive research on the appropriate types of fertilizers suitable for various soil conditions and crops was carried out and the result was tested for years. They introduced the practice of simultaneous pest control over a wide area collectively. The implements and machinery which appeared to be most suitable for the land were developed by the local people and gradually mass-production started when other affiliated technology was introduced in Japan from Europe and the U.S.A. The crop rotation, crop diversification and irrigation systems were also developed scientifically. The histrorical progress in agricultural machinery in Japan is shown in the **figures** 1 and 2 and in the **table 2.**

The government policy was self-sufficiency in rice production, and special emphasis was laid on proper solution to the problems confronting the farmers. The government policy of subsidy to the farmers, price stabilization and farm mechanization paid off satisfactorily —— resulting in over production of rice in 1967. Another important policy of the government was to raise the standard of living of the farmers by (1) raising their income and (2) by relieving them of drudgery associated with farming. This was achieved through farm mechanization, and production diversification (refer to **table** 4).

Figures 3 and 4 show the rapid increase in the production and use of agricultural machinery. **Table** 2 and 3 show the decrease in labor-hour and increase in rice production per hectare as the use of farm machinery increase.

Impact of Agricultural Policy on Japanese Economy

Japan started her economy with an effort to (1) increase agricultural productivity, (2) reduce farm population (3) absorb spare labor in small-scale industries (4) proceed to heavy industries basing on the experience and encouragement gained in managing small industries and (5) proceed to technology-based industries where own technology could be developed.

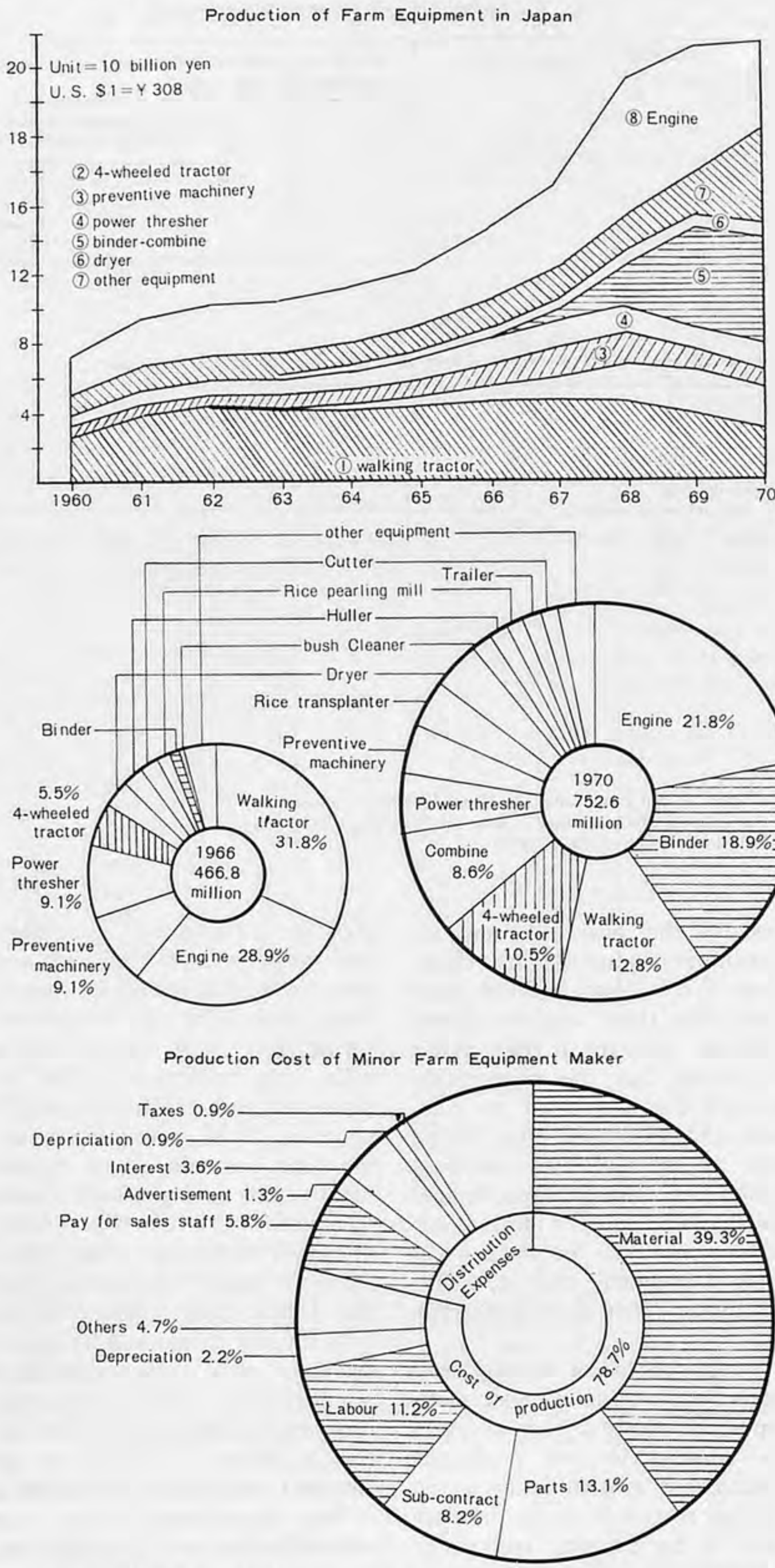
In the above process, farm mechanization played a crucial role in that

(i) Extra labor was created and

(ii) Farm household income increased —— which conditions are absolutely essential for large-scale industrialization. Necessary technological base being created fairly long time ago, the above two conditions could result in a sharp rise in industrialization and production. As industries developed, further farm mechanization took place and more farm population shifted to industries. The feedback process drastically changed the income structure of the farm household. (refer to **figure** 5 and 6 and also **table** 5)

This changed income structure coupled with government policy of price stabilization by establishing a higher producer price (for economic well being of the farmers) and a lower consumer price —— the balance being covered by government fund (Food Control Special Account), rapidly changed the income level of the farm household (refer to **figure** 7). The government agricultural policy covered all areas of agriculture, which contributed to higher productivity. A big 10% of national budget was appropriated for agricultural activities upto the end of 1960s. And again this agricultural budget was distributed for different agricultural activities in such a way that it collectively produced to optimum desired result. The distribution of agricultural budget for 1967 is

Figure 3. Agricultural Machinery Production Activities in Japan



Sources : (1) 1972 Farm Machinery Statistic by Farm Machiney Industrial Research Corp.
(2) Agricultural Mechanization in Asia, vol.2, by same as (1)

shown below as a typical example.

Main Items of Agricultural Budget in Japan, 1967

Price stabilization and marketing (Food control special account)	: 48.4%
Agricultural Production	: 29.4%
Calamities	: 11.0%
Mechanization and upbringing of viable unit etc.	: 4.9%
Improvement of living conditions in rural areas	: 0.5%
Agricultural bodies	: 0.5%
Agricultural research, education etc. etc.	: 5.3%

(Source: Agriculture in Japan——by Agricultural Policy Research Committee, Tokyo (1969))

The success of the government policy owes to the simplified but effective agricultural management and application of proven agricultural techniques.

In 1948 Japanese Ministry of Agriculture and Forestry implemented Agricultural Extension Service under the Agricultural Extension Service Promotion Law. This service is a part of agricultural education system which requires (a) the subject-matter specialists and (b) the agriculture extension workers to train the farmers directly through personal contact. Thus the agriculture techniques developed or improved so far by agricultural research workers (according to 1964 statistics there were about 14,200 research workers in 458 agricultural research institutions in Japan —— mostly doing research on asigned project) were introduced to the actual farmers. As of 1966, the extension service workers strength was as follows:

Agricultural Extension Workers

Types of agricultural extension workers	Agriculture	Home living
Subject-matter specialist	764	245
Adviser	10,626	2,350
Total	13,985 Persons	

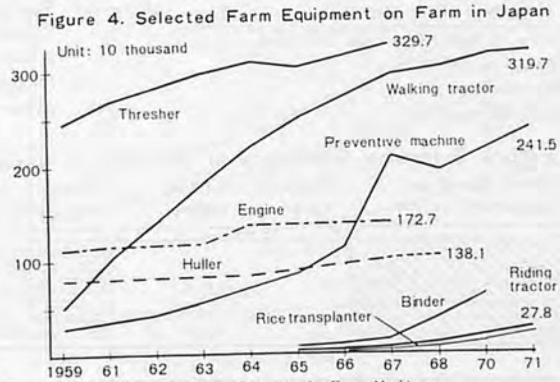
Source : Agriculture in Japan——by Agricultural Policy Research Committee, Tokyo (1969).

Table3. Rice(Paddy) Production & Yield

	(1000ha) Rice plant area			(1000t) Production			(100kg) Yield per ha		
	1952~1956	1967	1968	1952~1956	1967	1968	1952~1956	1967	1968
Asia	73,066	85,930	83,773	112,968	160,361	168,193	15.5	18.7	18.9
India	31,164	36,437	36,966	39,878	56,418	59,642	12.8	15.5	16.1
Bangladesh(1968)			9,484	(rice)		10, 995			12.3
Pakistan			1,404	〃		1,475			10.5
Indonesia	6,493	7,523	7,964	11,068	14,344	15,224	17.0	19.1	19.1
Thailand	5,345	5,601	6,799	7,236	9,595	10,895	13.5	17.1	16.0
Burma	3,990	4,934	4,976	5,980	7,714	8,485	15.0	15.6	17.1
Japan	3,108	3,263	3,280	13,498	18,770	18,765	43.4	57.5	57.2
Philippines	2,693	3,304	3,332	3,230	4,789	4,445	12.0	14.5	13.3
Viet-Nam,Rep.	2,290	2,296	2,394	2,939	4,588	4,366	12.8	20.4	18.2
Viet-Nam, North	2,120	2,550	2,674	3,420	4,700	4,920	16.1	18.4	18.4
Cambodia	1,720	2,020	2,324	1,663	2,457	3,251	9.7	12.2	14.0
Korea, Rep.	1,093	1,235	1,150	3,647	4,869	4,318	33.4	39.4	37.5
Nepal	1,308	1,119	1,200	2,486	2,217	2,322	19.0	19.8	19.4
China, Taiwan	775	787	790	2,178	3,162	3,299	28.1	40.2	41.8
China, Main	29,597			74,200	92,000	91,000	25.1		
U. S.	818	797	952	2,455	4,054	4,721	30.0	50.9	49.6
Brazil	2,287	4,291	4,459	3,319	6,792	6,657	14.5	15.8	14.9
South America Total	2,840	5,217	5,378	4,625	9,131	9,002	16.3	17.5	16.7
Europe Total	385	345	363	1,709	1,567	1,505	44.4	48.3	41.5
Italy.	167	144	151	855	745	639	51.3	51.8	41.1
Africa	2,862	3,474	3,704	3,790	6,715	7,102	13.2	19.3	19.2
World total	110,215	128,687	132,164	200,844	276,234	284,168	18.2	21.5	21.5

Source : (except for Bangladesh and Pak) 「FAO Production Yearbook 1969」

Figure 4. Selected Farm Equipment on Farm in Japan



Source: 1972 Farm Machinery Statistic—by Farm Machinery Industrial Research Corp. Tokyo

Agricultural management in Japan is excuted jointly by the government and the farmers and the democratic cooperatives play the vital role in all stages of implementations of policies. The main functions of agricultural cooperatives (multi-purpose and special purpose cooperatives —— local, prefectural and national) are (1) credit activities, (2) Purchasing, (3) Marketing, and (4) Mutual relief.

The marketing system depends heavily on the government food control policy and related fund. This policy also aims at selective and efficient expansion of production.

The government undertakes

Table 4. Production of Principal Commodities in Japan

	Rice	Wheat	Barley	Soybeans	Mandarin Oranges	Eggs	Cow's Milk
	1000tons	1000tons	1000tons	1000tons	1000tons	Million	1000tons
1959	12,501	1,416	2,308	426	766	8,150	1,714
1960	12,858	1,531	2,301	418	894	9,559	1,887
1961	12,419	1,781	1,976	397	876	12,863	2,114
1962	13,009	1,631	1,726	336	893	14,603	2,437
1963	12,812	1,716	758	318	974	15,300	2,761
1964	12,584	1,244	1,203	240	1,229	17,896	3,020
1965	12,409	1,287	1,234	230	1,331	19,625	3,221
1966	12,745	1,024	1,105	199	1,750	18,756	3,409
1967	14,453	997	1,032	190	1,605	23,307	3,566
1968	14,449	1,012	1,021	168	2,352	24,694	4,016
1969	14,003	738	812	136	2,038	27,898	4,509
1970	12,699	474	572	126	2,552	29,975	4,764

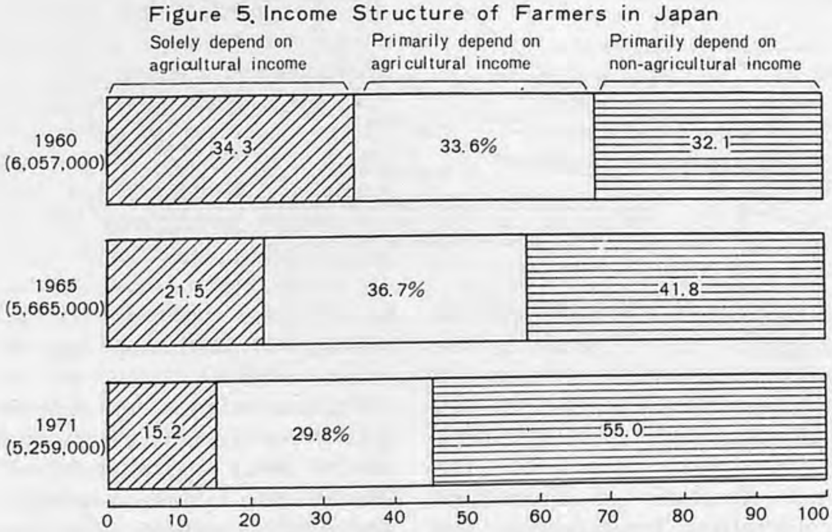
	Slaughtered Livestock: Carcass Weight		Logs Consumed for Sawing
	Cattle	Chicken	
	1000tons	1000tons	1000m³
1959	147.9	85.9	33,548
1960	142.4	96.3	36,431
1961	142.8	98.6	39,166
1962	146.1	111.3	39,885
1963	185.9	120.5	41,914
1964	223.9	142.3	44,308
1965	207.8	175.3	44,846
1966	156.1	249.9	47,558
1967	146.5	334.6	51,240
1968	160.2	403.2	54,274
1969	215.9	520.4	55,824
1970	260.5	595.9	56,929

Source: Ministry of Agriculture and Forestry.
Note: 1. Including naked barley.
2. Including calves.
3. Including jeck mackerel.

	Dairy Cattle
	1000
1946	—
1950	198
1955	421
1960	824
1965	1,289
1966	1,310
1967	1,376
1968	1,489
1969	1,663
1970	1,804

Secondary Source: Statistical Survey of Japanese Economy, 1971——by Ministry of Foreign Affairs, Japan.

Figure 5. Income Structure of Farmers in Japan



Note: The number of agricultural households in parentheses
Source: Industrial Review of Japan 1972

direct investment in forming fixed agricultural capital by taking the responsibility for (1) land improvement, (2) prevention of or relief from natural disaster, (3) irrigation and drainage, and (4) reclamation. It may be noted that direct government investment and other agricultural investment resulted in an agricultural fixed capital formation amounting to 7.2% of the total domestic fixed capital in 1966.

The marketing channels of rice are shown in **figure 8.** The cooperative organizations system is shown in **figure 9.** The loan distribution by financial institutions and farm household deposit allocations are shown in **tables 6** and **7.**

The producer and consumer prices were arbitrarily fixed (refer to **figure 7**). After about 26 years, when the economic structures and levels are changed, the fixed consumer price system has recently been abolished with effect from April 1, 1972.

To sum up the agricultural system in Japan, it can be said that the system is definitely an ideal representation of economic solution to the agricultural production input-output problem —— in that the basic production inputs, (1) cultivation techniques, (2) skilled labor, (3) seed, fertilizers and pesticides, and (4) agricultural machinery could be put together on the farm land for higher production without foreign loan. This system could however be a failure, had the government aimed at anything other than raising the economic level of the farmers through higher productivity —— even at the cost of billions of dollars as subsidies and direct agricultural capital investment.

Applicability of Japanese Agricultural Development Process

All the developing countries want to increase their agricul-

Table 5. Effect of farm mechanization on the economic condition of farm household in Japan

Year	1945	1950	1955	1960	1965	1966	1967	1968	1969	1970	1971
Machine Power, H.P. /ha of rice			0.1	0.7	2.4	2.6	3.1	3.3	3.7		
Labour hour/ha of rice		2,050	1,920	1,706	1,385	1,361					
Agr. population, % of total labour force	49.9	45.2	33.3	28.0	20.6	19.4	18.8	18.0	17.0		16.8
Cultivated land per household, ha	0.70	0.81	0.84	0.95	1.06	1.07	1.08		1.09		
(Farm households)											
Full time, %	53.5	50.0	34.5	34.3	21.6	20.9	21.2	20.0	15.6		
Part time, %	46.5	50.0	65.5	65.7	78.4	79.1	78.8	80.8	84.4		
Total, number unit = 1000	5,698	6,176	6,043	6,057	5,665	5,500	5,417	5,351	5,342		
Rice production per ha, 1000 kg		3.20	4.34			4.53	5.75	5.72			
(Production cost of 150kg of rice)											
Agr. machinery cost U.S.$			1.15	1.77	4.33	4.74	5.05	5.94	9.53		
Labour cost, in U.S.$			9.19	9.67	17.10	18.31	18.95	20.57	22.59		
Total cost in U.S.$		13.0	17.7	19.3	31.9	34.4	39.1	43.6	50.7		
(Average farm household income)											
Agr. income, U.S.$		479	832	731	1,186	1,345	1,656	1,711	1,719		
Non-agricultural income, U.S.$		194	333	598	1,284	1,455	1,687	1,974	2,376		
Total, U.S.$		673	1,165	1,329	2,470	2,800	3,343	3,685	4,095		
Living expenditure farm household U.S.$				1,196	2,125	2,358					
Surplus farm household U.S.$				133	345	422					

Source : Changes and Mechanization in Agriculture
1972 Farm Machinery Statistics
Agricultural Mechanization in Asia, vol. 2
--All by Farm Machinery Industrial Research Corp. TOKYO

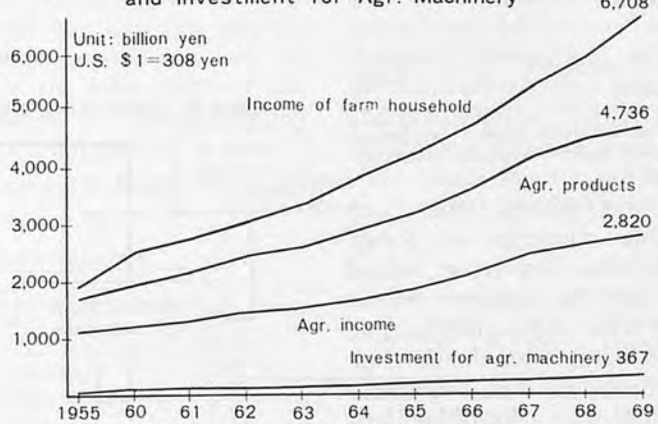
(1PS = 1h.p. 1ha = 2.471acre $1=308yen)

Table. 6 Status of Approval on Loan by Financial Organizations in 1966.

Agricultural cooperative Association:	47.3%
Agriculture, Forestry and Fisheries Finance	21.6%
Federation of Credit Agr. Cooperative Associations.	20.0%
Central Cooperative Bank for Agriculture and Forestry:	4.2%
City and local Banks:	2.9%
Credit Cooperative Association:	2.0%
Mutual Savings Bank:	1.4%
Others:	0.6%

Source: Agriculture in Japan——by Agricultural Policy Research Committee, 1969.

Figure 6. Agr. Products, Income of Agr. Farm Household and Investment for Agr. Machinery



Source: 1972 Farm Machinery Statistic
-by Farm Machinery Industrial Research Corp. Tokyo

tural production but with very limited or no success. The age-old practice is already at its maximum efficiency. So "more production" means "new agricultural techniques". Lately good techniques are also in practice in the advanced countries. The developing countries can appreciate the new techniques but can't apply them properly due to good many reasons, some of which are given below:

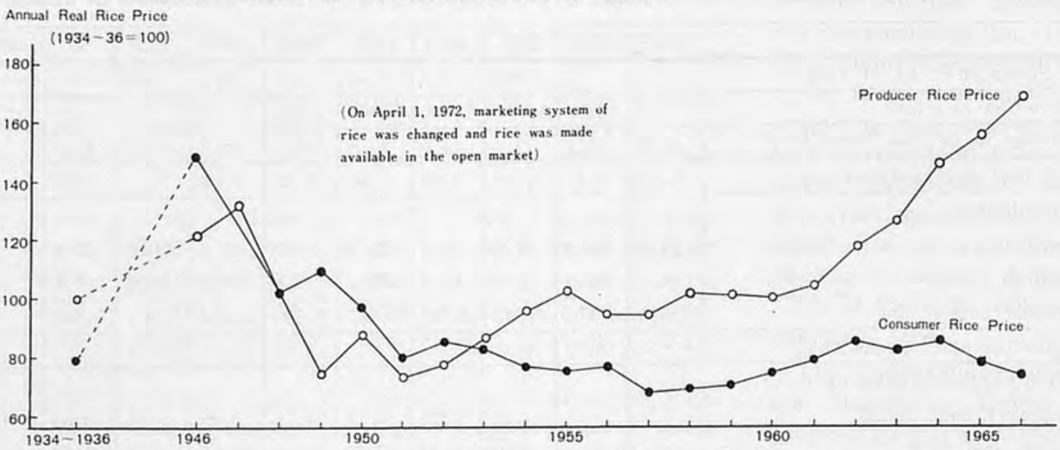
(1) There is no universal cultivation process equally applicable to all environment, so the techniques developed in the advanced countries are not applicable to the developing countries without some adaptive research which the developing nations usually don't try properly.

(2) The developing nations are too poor to be in a position to provide all the production inputs to the farm for increased production.

(3) Agricultural management and marketing are not sufficiently developed.

Japan in her early developing

Figure 7. Producer and Consumer Rice Price in Japan



Note(i) Producer rice was deflated by wholesale price index.
(ii) Consumer rice price was deflated by consumer price index.
Source: Agriculture in Japan — by Agricultural Policy Research Committee, Tokyo (1969).

Table. 7 Deposit Balance of Farm Household in Different Financial Organizations in 1966.

Agricultural Cooperative Association:	59.0%
City and Local Banks:	22.3%
Post Office:	10.3%
Mutual Savings Bank:	4.2%
Credit Cooperative Association:	3.6%
Fishery Cooperative Association:	0.6%

Source: Agriculture in Japan—by Agricultural Policy Research Committee, 1969.

Figure 8. Marketing Channels of Rice in Japan

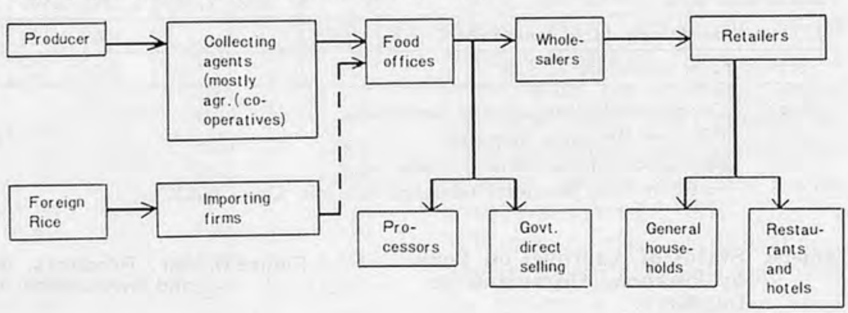
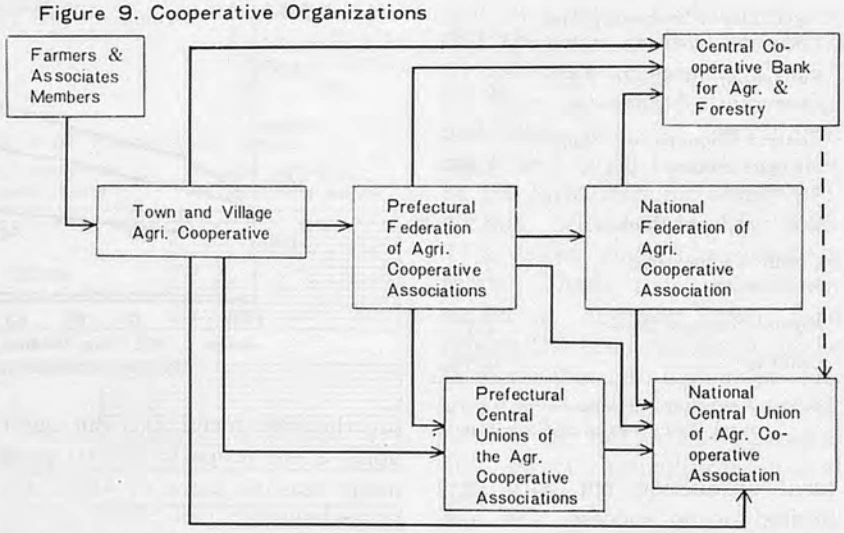


Figure 9. Cooperative Organizations



stages was poorer than any developing countries of today. But her concerted effort helped her get over the problems. So the process, with slight modification, is , quite suitable for the developing nations in Asia, specially Bangladesh with a lot of similarities with Japan. But one would make blunder to consider agricultural development separately from other related development.

The inputs necessary for increased production are

(1) Improved cultivation techniques (to be practiced by the actual farmers)
(2) Better seeds
(3) Fertilizers and pesticides,
(4) Irrigation and drainage system i.e. water control,
(5) Labor, and
(6) Power

The input (1) i.e. improved cultivation techniques, can be introduced to the farmers through agricultural extension workers, as in Japan and the agricultural techniques themselves can be improved through adaptive research carried out in the field and in the agricultural research institutes, basing on the maximum of knowledge available around the world.

The input (2), i.e. better seeds, can be available by proper seed collecting techniques but they must be scientifically preserved. Initially import may also be considered.

The input (3) i.e. fertilizers and pesticide, requires big chemical plants for their production. But, if heavy industries for making fertilizer plant can be developed many fertilizer factories can be made quite economically. Pesticides which do not badly effect the environment must be selected even if they may be costlier.

The input (4) i.e. irrigation and drainage system, is the one which demands billions of dollars. In Bangladesh there are many big and small rivers which destroy huge amount of crops by flood. Again in Winter, cultivation is not possible because of shortage of water. So water control deserves special priority, but if any attempt is made to make dam or embankment with direct foreign loan, or to buy pumps with foreign exchange earnings, there will never be an end to the actual problems. On the other hand, techniques to build embankment and dams, and facilities and know-how to manufacture pumps should be imported. Of course, steel factories and cement factories must be set up as early as possible.

The input (5) i.e. labor necessary for intensive cultivation, is not always available, even though 60 to 90% of working population are said to be engaged in agricultural activities in the developing countries. In Bangladesh, over 85% of the working population is engaged in agriculture. Then can it be said that agricultural lobour is not sufficient? The answer is definitely "yes". Firstly the cultivation period is concentrated over a short period of summer. Secondly, the summer noon is too hot (80°F to 100°F) for field work at full efficiency. Thirdly, the health of the average farm workers is not good enough for sustained work. Fourthly, unaided by any suitable implements, the aged farmers are kept out of actual farm work by the drudgery associated with farming. So out of the total available labor-hours of the farm population, only about 10 to 20% is used for actual farm work. This wastage of valued labor can however be stopped by ——

(a) farm mechanization,

(b) health service improvement,

(c) provision for night work facilities (lighting etc.),

(d) round-the-year cultivation practice (by crop rotation and multiple-cropping with proper water control —— this can further be improved by making vinyl or glass houses to grow seedlings in advance for the next crop, while the field is still having a crop on. This is to minimize the gap between two crops),

(e) agricultural mechanization (as the animals used for agriculture can not be used for work throughout the day the farmers are automatically put out of work for the long hours of the day, except in transplantation and cultivation period),

(f) establishment of small-scale (possibly seasonal) industries near the farm villages —— to profitably absorb the extra labor created by the farm mechanization,

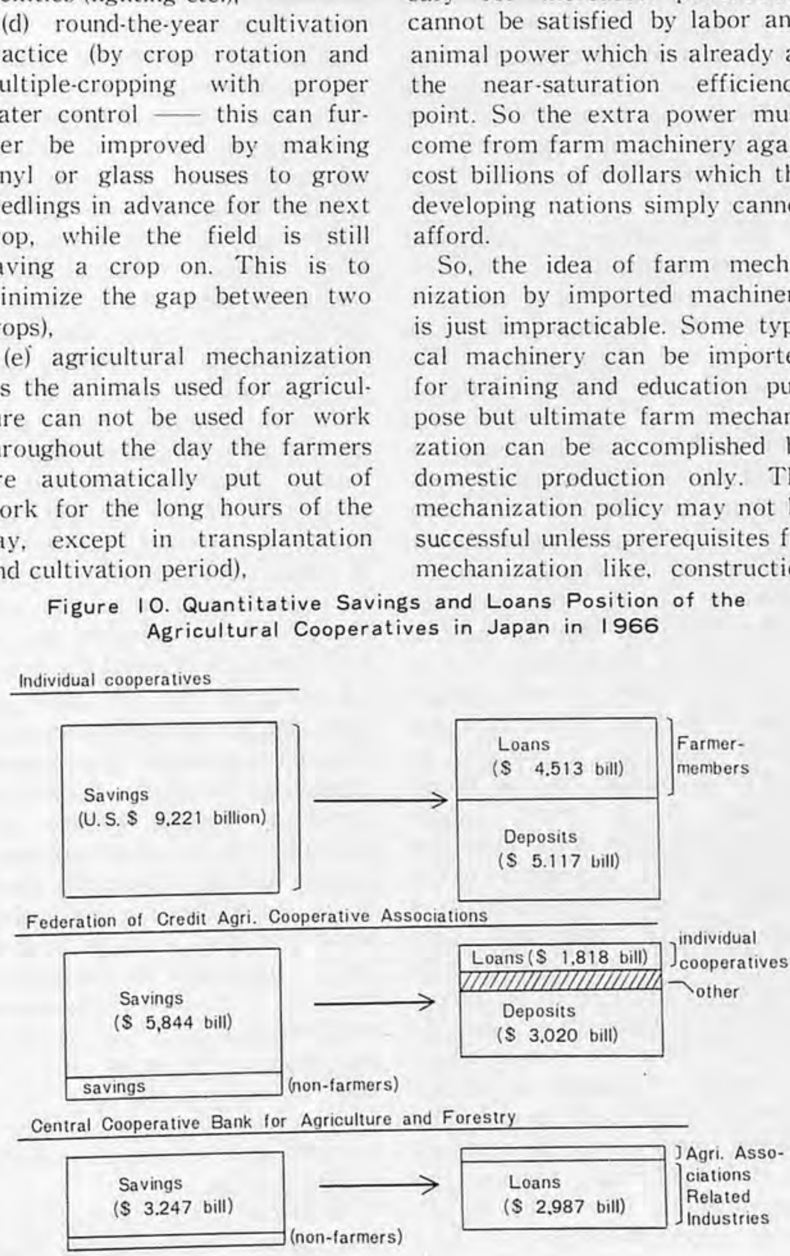
(g) establishment of small-scale poultry and dairy farms (these cannot grow unless marketing system and processing industries are improved by government initiative or by the cooperatives), and

(h) improvement of transportation.

The input (6) i.e. power necessary for increased production, cannot be satisfied by labor and animal power which is already at the near-saturation efficiency point. So the extra power must come from farm machinery again cost billions of dollars which the developing nations simply cannot afford.

So, the idea of farm mechanization by imported machinery is just impracticable. Some typical machinery can be imported for training and education purpose but ultimate farm mechanization can be accomplished by domestic production only. The mechanization policy may not be successful unless prerequisites for mechanization like, construction

Figure 10. Quantitative Savings and Loans Position of the Agricultural Cooperatives in Japan in 1966



Farmers using a mechanical thresher in Comilla, Bangladesh

of farm roads, purchasing capacity of the farmers, small-scale industries to absorb extra labor, and farmer's education, are met by government-farmers joint effort.

Having realized at this point that the production of farm machinery must be made domestrically, a few questions arise as to how to and where to start. The answers are slightly different depending on technological and industrial level of the country in question, but the industrial process remains the same. In many cases, technological ignorance on the part of the short-term policy makers makes the situation unfavorable for healthy starting of domestic production —— in that they think of end product separately from other products which may also be directly or indirectly related to the target product. As a result, proper budget allocation is not made for the right items. In response to the policy of home-production, it is seen that the agricultural ministry tends to come forward with a proposal for a financial allocation for a large-scale assembly factory of tractors, power tillers or pumps —— basing on foreign parts of a particular model. The foreign parts cannot be replaced by the local-make, because the local makers, if existing at all, cease production due to their inability to compete in quality and good finishing. This prolongs the period of dependence on costly foreign products, and dampens the development of design engineering which is essential for developing the most suitable farm machinery domestrically in the environment of the farms in question. This policy may still however work in a country with a comparatively small need and enormous resources. For a poor country like Bangladesh with no natural resources but with a population of 75 million and having no technical base worthy of name, the approach to domestic production must be very well concerted —— founded on coordinated technological discipline.

Fortunately for the poor nations, the agricultural machinery does not require any complicated technology except for (1) the internal combustion engines, (2) hydraulic system, (3) transmission system, and (4) instruments. Each of this specialties can be studied separately and working models can be developed by incorporating the necessary information available to-day. The shortest and probably the most effective way to achieve this end is to invite foreign experts on a four to eight years contract in all the technical areas.

As to the budget allocation for this purpose, the authority must appreciate that these technologies are not the investments for agricultural machinery alone. Once these are developed to an extent, major construction machinery and transportation equipment can be produced locally by introducing only minor supplementary technologies. Now at this point a few procedural questions arise as to

(a) whether the production of the final product should wait for the development of the abovementioned technology-based subsystems

(b) whether large-scale assembling should start as the demand for the machinery increases, without regards to the development of the above subsystems.

or (c) whether all the aspects of production, training, research and development, design, application and marketing efforts should begin in parallel and in small scale, having provisions for rapid growth as soon as sufficient technology is accumulated. (Initially some subsystems or components may be imported)

The answers to these questions depend on the amount of budget the government can afford to allocate, the time allowable before mass production is envisaged, and also the quality of the product desired. As almost all the developing nations want to achieve the target in a minimum of time, with minimum of foreign exchange and with maximum of employment created, the question (a) cannot be considered. The answer to (b) is related to the political and social system of the country in question. In purely capitalistic countries the answer is "yes", but in the developing countries, the government intervention is too frequent and as such productions need not depend on the expressed demand. The government can easily create such demand with a wise manoeuvre of policies. So, for the developing countries, especially ones like Bangladesh the answer to (c) is definitely "yes". Probably this is the only way which will be compatible to the economy and technological level of these countries. The success will however depend on strong technological coordination.

It is worth noting that the inputs to the production are very simple and the initial investment is not too big. A good starting can be made with the following basic facilities, materials, and personnels:

Facilities:

(1) Welding machines

(2) Small-scale casting facilities for

Iron

(a) ordinary type

(b) high quality type

Alumunium

(c) alumunium casting facility

(3) Machining facilities

(a) for making standard gears

(b) for making shafts

(c) heat treatment facilities

(d) general tools

(4) Forging facility (small-scale)

(5) Press

(6) Quality control and testing facilities

Materials:

(1) Steel

(2) Special steel

(3) Alumunium and alumunium alloy

(4) Corrosion-proofing coatings

Personnels:

(1) Welders

(2) Mechanical engineers (general purpose)

(3) Metallurgical engineers

(4) Design engineers

(5) Quality control and R & D engineers

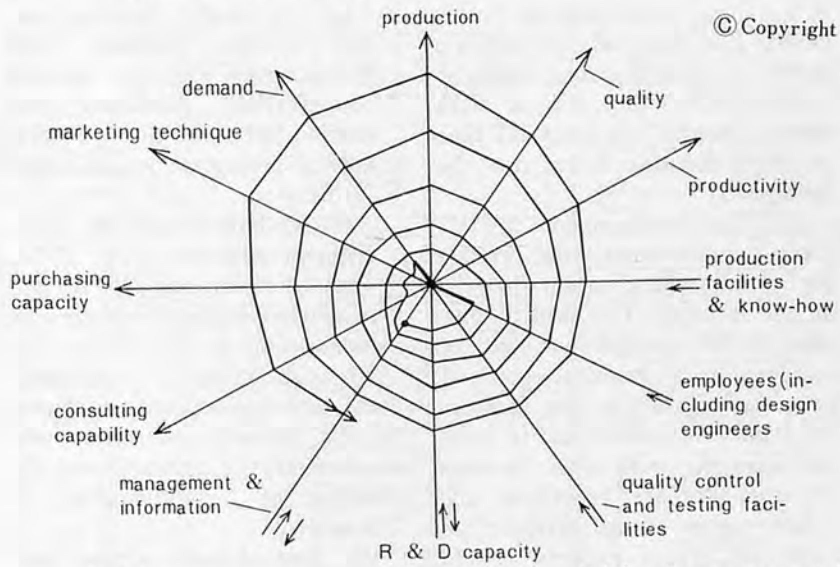
(6) Electrical engineers

(7) Technicians, and

(8) Office staff.

Note: Many implements and parts can be made by local carpenters and blacksmiths if they are given proper design instructions by the design engineers.

Figure 11. Pattern of accelerated growth of individual industries from a modest starting



It may be borne in mind that a modest starting does not mean a modest rate of growth. A very high rate of growth is possible economically if things are in proportion and the men involved are led to a position where they can display their creativity which is immeasurable by economic scale (refer to **figure 11**).

After analyzing the agricultural production-inputs, it should now be clear that all the inputs are not independent of one another. Even the basic components of agricultural machinery can be assembled in multitudes of ways to produce different types of other equipment limited only by the imagination of the design engineers. The individual products like power tiller can also be used for varied purposes other than farming. To mention a few such uses, a power tiller of medium power can be utilized as a

(1) Tiller

(2) Power thresher (with minor accessory)

(3) Power transplanter (with minor accessory)

(4) Harvester/cutter (with minor accessory)

(5) Pump (with minor accessory)

(6) Power sprayer (with minor accessory)

(7) Power generator for lightings at night or as a power source for small workshop or welding machine (with minor accessory)

(8) Saw mill or grinding machine

(9) Ice factory and refrigeration system for food preservation (with minor accessory)

(10) Transportation equipment for agricultural materials (with minor accessory)

(11) Power source for boats, and as many as many others which need a power source.

Now at this point it can be said that effective agricultural planning is possible only after thorough evaluation of all the related aspects described so far in this subsection. The implementation of the planning is however quite involved and it is to be done through well-organized institutions which necessarily establish a link between the farmers and the policy makers. Japanese system can provide a good example for the developing nations.

Some recommendations are however given below for Bangladesh which is a typical developing country in Asia:

Management:

(1) The country be divided into some agricultural zones having common features, and the zones be divided into villages or unions (as existing now or with some changes, but political bias or exploitation must not be indulged).

(2) The management in this three tiered system must provide for direct participation by the actual farmers. The central purpose of the management shall be to develop a genuine sense of cooperation among the farmers for their own benifit and to raise the economic level of the farmers for the ultimate benefit of the entire nation. (Local farm enthusiast and farm experts should gradually dominate the management within the framework of overall agricultural policy of the government).

The organizational units may be village cooperative, regional or zonal cooperative and the national or central agricultural cooperative, almost exactly in the line of Japanese system (refer to **figures 9** and **12**)

Finance: (refer to **figure 13**)

(3) Government Agricultural Development Bank may work as the Central Agricultural Cooperative Bank and may not have any administrative power. Its main purposes would be

(a) to render banking service to the farmers, local cooperatives and the regional cooperatives (including extension of credits to the deserving cooperatives or individual farmers)

(b) disbursement of government subsidies

(c) national and international market research for agricultural products.

(4) Agricultural machinery development cost may be shared by the ministry of agriculture, the ministry of industry, and the ministry of Communication & Transport.

(5) Cost of multi-purpose project for electricity, irrigation and water control may be shared by the corresponding ministries jointly

(6) Embankments which can be converted into highways or ordinary double-lined roads may be financed by the ministry of agriculture and the ministry of Communication & Transport.

(7) Foreign Loan or Grant may not be used for direct foreign purchase of services and finished machinery. In stead, related facilities and know-how may be imported, after base for accepting advanced know-how is created with substantial investment.

(8) Marketing development cost may be subsidized by the ministry of agriculture.

Agricultural Machinery Industries:

(9) The government may establish an Agricultural Machinery Study committee with the following task.

(a) to collect all available information on the types and use of all available agricultural machinery around the world.

(b) to make preliminary evaluation of the above machinery

(c) each member to lead a group of working engineers to field-test and modify the machinery to suit the local conditions. (later on this work can be carried out by extension workers)

(d) the committee to report the complete result of the study to the machinery and component development engineers (refer to **figure 13**) and continue the similar work till sophisticated machinery reach mass-production stage. (within 2 to 5 years)

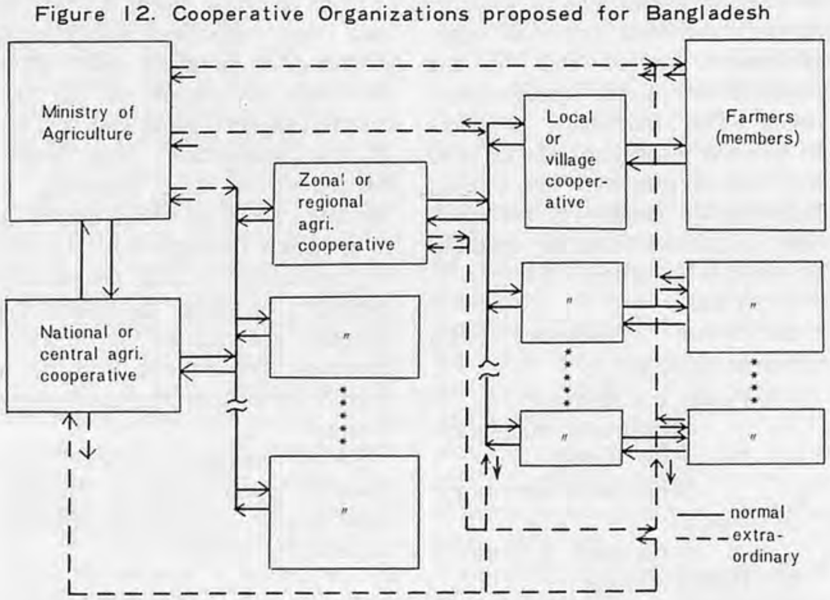
(10) The government (as shown in **figure 13**) may establish agricultural, construction, and transport machinery development research centre (for design and production process research for specialized items and components)
(some specific problems may be assigned to the related teachers in colleges or universities for finer study)

(11) Small-scale component production facilities should be installed.

(12) Assembly and testing facilities should be installed at different suitably located places around the country.

(13) Machinery service centre must be established in evey union or at least one in every two to four unions,

Figure 12. Cooperative Organizations proposed for Bangladesh



All these steps should be scheduled properly and almost all of them can be started in parallel but they must be in proportion compatible to economy and the technological level of the country.

(14) Production of pumps and tube wells however, may be started almost right away.

[Agricultural mechanizaion carries with it a cause of public nuisance "Sound Pollution" which the initial planners usually overlook. As the machinery last for many years, proper sound absorbers should be provided from the very beginning even if it involves a higher cost.]

Water Control:

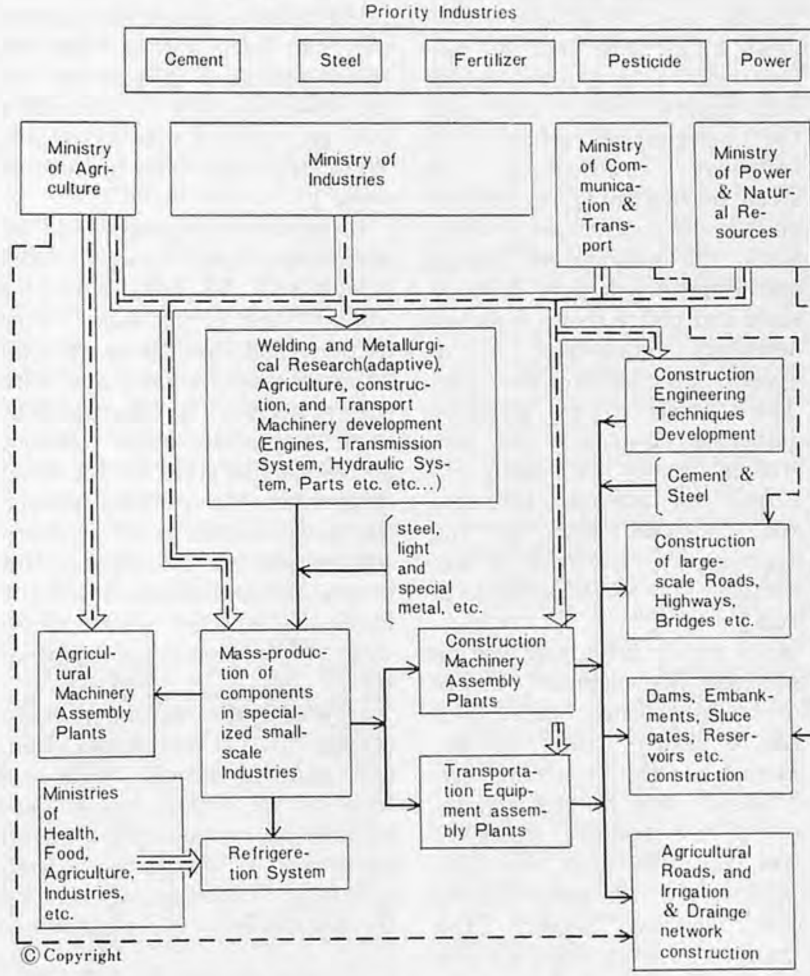
(15) The government may appoint a Water Source study committee and the members be re-educated as to how to study and collect data on the behaviour of rivers and streams, location of reservoirs, sluce gates etc. etc. To minimize the time required for study (one complete year), the committee may function in the following way.

(a) Each member of the committee may lead a small group of young engineers to carry out in study of one or two rivers or streams with frequent consultation with the local people on both sides of the rivers. (The study may include total yearly flow of water, maximum and minimum flow, minimum height of the area on both sides from the river bed, possibility of dams and other related aspects)

(b) Each group will prepare an elaborate map of its area with all technical data derived from the study.

(c) The committee may report the result of the study with comment to the joint committee of construction engineers who will analyze the data, formulate the working plan and prepare specifications and also possibly drawings according to which work on

Figure 13. Inter-relationship between Agricultural Machinery Industries and other Development Inputs.



NOTE : Scheduling in respect of time, labor, and fund may easily be worked out on the basis of PERT or CPM.

- - →: financial support;
——→: technical support.
: through local or local-foreign joint consulting expertise.

══⇒: financial support including big foreign exchange component

dams, barrages, reservoirs, embankments, embankment-roads, sluce gates, canals, drains, irrigation-network system, etc. will be started in parallel throughout the length and breadth of the country.

The work demanding higher technical know-how and costly machinery may be started after the technology is acquired by the Construction Engineering Technique Development Group, and the machinery comes out of the assembly line (refer to **figure 13**). In order that less complicated large-scale construction work can be started right away with the presently available small number of engineers, local people can be trained in groups for specific projects, by the construction engineers qualified for the purpose and some incentive may be introduced for devoted work. [any tendency on the part of the Government engineers to supervise the entire work under their own control may lead to a miserable failure. The engineers themselves must work with a group of people so as to completely ascertain the appropriateness of the specifications laid down for the work. The government must make sure that all the local contractors are equiped with qualified men to carry out the assignment within the technical specifications. In stead of tightening restrictions on the new contractors to enter work the government should encourage newcomers in large scale and oblige them to gather necessary know-how as a general precondition for continued work. In the stage of gathering know-how the government must be ready to extend all possible technical and financial help to the newcomers irrespective of any political or social consideration.]

(16) A construction Engineering Techniques Development centre may be established, which will make extensive study of the modern construction technology, and adapt them to the requirement of the country (refer to **figure 13**). The best workable techniques would be spread to the actual working people. The teachers of the engineering institutes and universities may be compelled to carry out part of this work as a precondition for their professional recognition.

(17) A joint committee of construction engineers may be appointed. The members should be actual working experts and would be drawn from (a) the Construction Engineering Techniques Development Centre, (b) the Water Source Study Committee, (c) the construction companies (d) the constractors, and (e) institutes or universities actually carrying out extensive research work in the field. [In all the cases above, the word "committee" has been used to represent a group of persons responsible for a definite work to the very implementation stage and the members are supposed to be technically qualified to guide the assigned work at all stages. They are also required to be educated, re-educated and up-dated so that they can keep abreast with the latest technical development in the respective field. A committee may also have a number of subcommittees for more specialized work.]

(18) The management of the committees and other related setups will be responsible for smooth flow or technical information and assistance to all levels of workers associates with the projects. The management must appreciate that without active participation of the huge number of the working people, the development of the country will remain an imagination. But people can participate in work if they are equiped with precise working knowledge and information.

(19) Land reform, at least to the extent that irrigation, drainage, and agricultural roads systems can be constructed smoothly, may be carried out with full protection of the farmers from arbitrary decision by any authority whatsoever.

Agricultural Education

(20) As in Japan and also in many other countries, the government may introduce agricultural extension service with a clear aim to provide the farmers with proven agricultural techniques most appropriate for the locality of the farmers in question.

(21) Demonstration farms should be established in every village or union. Apart from demonstration of cultivation techniques, the model farms must prove that they can increase the farmers' income by the new methods. The model farms will be required to run at a profit and they must use the established marketing channels of the local cooperatives. (Along with routine demonstration, special research on the local agricultural problems can also be carried out)

(22) Agricultural Research Institutes may be established in different parts of the country, where specific problems can be best studied. The major emphasis will be laid on increased production without worsening the environment. Cattle raising, poultry and dairy farming, fruit cultivation etc. should also be the subject of through study. The result of the study should reach the farmers through the extension workers for practical application.

(23) Documentary movies on agricultural techniques used on other parts of the world should be shown to the farmers frequently.

(24) Television, being one of the most effective media, should be introduced in the countryside even if it is not introduced in the big cities immediately. Every farmer may not have a set, but at least a few sets can be installed in public places.

[Television should not be considered as a luxury item. Its effect is far-reaching. The economic burden on the government in terms of foreign exchange may not be big if related industries are established as shown in later subsection under the title "Electronic Industries".]

Marketing and distribution: (of machinery and farm products)

(25) Before mass-production of agricultural machinery starts and economic level of the farmers goes up, a government sponsored or a government subsidised farm machinery renting service may be established in every village or union. The first priority may be given to pumps, tube wells, sprayer, dryer (specially for "Aus rice"), power tillers, and possibly threshers and transplanters after a few years. This renting service must be backed by full repair facilities and smooth management, so that maximum available machine-hour

can be utilized. This service may however be operated by the local cooperatives at a later stage.

[There should not be any unnecessary rush to mechanize the farms with imported products unless domestic production facilities are ready. Extensive demonstration used to be necessary to bring about a change in the attitude of the tradition oriented farmers. Now the attitude of the farmers are already changed in favour of farm machinery. So demonstration effect will not do much good unless the basic problems of (a) farm management (b) raising of the economic level of the farmers, and (c) domestic production with ensured repair service are tackled by adopting recommendations made earlier.]

(26) The farm products may be marketed through channels in line with the Japanese ones discussed earlier. The government must commit itself to price stabilization by fixing producer and consumer price for all important agricultural products. The producer price must be higher than the consumer price —— the balance coming from the government fund. This is to serve double purpose of raising economic level of the farmers and suppressing profiteering which otherwise may push the consumer price to a dangerously high level at the time of food shortage. When the productivity increases the government may encourage selective expansion of the products basing on national and international market condition.

The above recommendations, if implemented properly, may produce a positive result, but to achieve a balanced national development, agricultural problems should not be considered separately from other basic problems like population growth check, removal of illiteracy, health service improvement, transportation improvement etc. which are directly related to every individual's daily life. In the initial stages, enormous restraint is necessary and careful planning is indispensable. It is the people who will ultimately be responsible for the implentation of the plan. So the government must convince the people of its sincerity, capability, and effort to achieve a goal which will be made known to the people through all information media and through direct contact. ■ ■

Farmers using Japanese weeder in Comilla, Bangladesh

REFERENCE : There are a number of well written articles dealing with agricultural cultivation techniques, mechanization process and economic consideration of agricultural mechanization in the developing countries, especially in Asia. Among such important articles which can help the agricultural planners, the following can readily be mentioned.

(i) Rice cultivation and Mechanization in South East Asia —— by Morio Kamijo, Chief of secretariat, International Agricultural Mechanization Research Service (Tokyo, 1971)

(ii) Some points to Improve Machinery for Rice production in Asian Developing Countries — by Morio Kamijo

(iii) Historical View of the Development of Agricultural Machine Industry in Japan —— by Yoshikuni Kishida, Chairman, Shinnorinsha Co., Ltd. Tokyo Japan (Agricultural Mechanization in Asia Vol. 2, 1971)

(iv) Some Critical Steps in Achieving Agricultural Mechanization in Developing Countries —— by Ernest T. Smerdon, Professor in the Department of Agricultural Engineering, University of Florida, U.S.A. (Agricultural Mechanization in Asia Vol. 2, 1971)

(v) Mechanization of Agriculture in Pakistan, Present Status and Future prospects —— by N. Ahmed (Agricultural Mechanization in South East Asia, Spring. 1971)

vi) A Proposal for Agricultural Mechanization in the Developing Countries of South East Asia —— by Howard F. McColly, Professor Emeritus, Agricultural Engineering Department, Michigan State University, U.S.A (Agricultural Mechanization in South East Asia, Spring 1971)

(vii) The system of Education & Research —— The Nucleus of National Prosperity —— by Mustafizur Rahman, Pakistan Space & Upper Atmosphere Research Committee (SUPARCO), Karachi, August, 1967.

NEWS

ISAE Tenth Convention, Jabalpur, Feb. 3 to 5, 1972; Special Session on

BOTTLENECKS IN AGRICULTURAL ENGINEERING INDUSTRY AND TRADE

INDIAN SOCIETY OF AGRICULTURAL ENGINEERS

(Secretariat: R-531 New Rajendranagar, New Delhi-60)
7, Neeltarang, 208 Veer Savarkar Marg, Bombay 16-DD.

On the occasion of the 10th Annual Convention held at Jabalpur, Indian Society of Agricultural Engineers arranged a special session on the 3rd February 1972 on problems of the industry. The session was well attended by members representing all the concerned sectors such as the Industry, the Government, the Agro-Industries Corporations, and the Academy, whose interest in particular lies in Research and Development.

Some important recommendations of the session are:—

1. Assessment of Demand

1.1 It is agreed by all that demand requires to be properly assessed for major input items such as farm tractors, power tillers, pumpsets (diesel engine and electric motor driven), combines and threshers, plant protection equipment and processing equipment. Demand also has to be assessed for fuels and lubricants, replacement parts (including tyres) and important items of raw materials, particularly steel.

1.2 It is suggested that agencies like the National Council of Applied Economic Research and the National Sample Survey organization be entrusted with the task of assessing demand for various items including a break-up of the demand State-wise and specification-wise. Agricultural Universities with well organized departments of Agricultural Engineering can also assist in assessment of regional demands. ISAE has initiated some work in this regard and will be pleased to co-operate with various agencies in this important work.

2. Development of Markets

Development of rural markets is slow and expensive. The situation is more difficult for farm equipment inputs. Lot of efforts and finance are required to develop markets for new technology and popularise it. It is necessary to grant suitable incentives to organizations engaged in this task and also to take into account expenses so incurred while determining prices and fixing selling expenses.

3. Finance

3.1 Aggregate annual investment in farm equipment inputs is enormous; for some important items excluding processing equipment, current estimates are Rs. 600 crores a year. Financing institutions should gear adequately to meet requirements of this magnitude.

3.2 Financing procedures require to be streamlined. Timeliness of making finance available to the farmer is critical, in view of his seasonal requirements. Such matters have been under study by the Reserve Bank of India and other agencies and their recommendations require an early implementation. Procedure for grant of loans requires to be simple, prompt, practicable and should be suited for handling a vast number of loan applications and servicing a large number of borrowers.

4. Production

4.1 The indigenous industry should be given all possible assistance in stepping up production. This should include steps to ensure regular supply of raw materials, ancillaries and machine tools. Some items which have been in chronic short supply are steel, pistons, rings and liners, thin walled bearings and fuel injection components. High carbon alloy steel which is required by the Disc manufacturers is not yet rolled by indigenous steel plants.

4.2 Licensing of industry should have some logical relationship with practical and sustained demand of the product and its possible export. Indiscriminate licensing of indigenous production capacities and introduction of a large variety of makes are creating several difficulties, including problems of maintenance and after-sales-services to the farmers.

5. Pricing

5.1 A major input, the farm tractor, is under the purview of price and distribution control orders. The drill for fixation of price should be prompt and should allow reasonable margin for manufacturing and marketing operations. In view of the prompt availability of tractors now, the necessity of a distribution and sale control order on tractors may be reviewed.

5.2 Most items of farm equipment industry now attract 30% import duty. Tractors attract 10% excise duty. Then, there are Central and State Government sales tax, octroi and other levies. All such imposts add to the cost of the input to the farmer. It should be appreciated that high cost of input will result in increasing cost of farmer's out-put as well. Items like combines and power tillers are new technology to Indian farmer and it is recommended that such items are exempted from such a high incidence of taxation, in particular the import duty, at least for an initial period of five years.

6. Logistics

6.1 Training of owners and operators and, in fact, all those connected with farm equipment is urgent. It has to be on a mass scale. It is recommended that Government of India establish on an urgent basis an institution in the form of a National Institute for Training in Agro-services (NITA) on the lines of the National Institute of Training in Industrial Engineering (NITIE) in Bombay. The institute will primarily train trainers, develop syllabus and bring out training aids including audio-visual material and educational films. It is necessary to grant incentives to the industry, the farmer-user and to the training institutions so as to give a fillip to the training programme.

6.2 Fuels and lubricants are an essential and major input for farm equipment operation. It is recommended that the Government of India establish a Farm Fuels Advisory Service to deal with all the problems connected with fuels and lubricants for farm primemovers.

6.3 To accelerate the growth of the farm equipment industry, it is necessary to provide a forum which will bring together the industry, the government, the academy, the public sector corporations, and the farmer-user. ISAE has earlier recommended establishment of an autonomous National Farm Equipment Council for this purpose. The proposal has also been unanimously supported by the Development Council for Automobiles and Allied Industries. It is recommended that this proposal be implemented by the Government of India without losing any further time.

6.4 Farm mechanization has contributed significantly to improving farm productivity. There is a lot of scope for farm mechanization to contribute more towards greater farm production. While reviewing land reforms, in particular determining ceilings on land holdings, it is important to ensure that the ceilings are liberally fixed at a level that will not hinder increase in farm productivity or spread of farm mechanization and that will ensure a reasonable standard of living and provide incentives for new and improved technology to the farmer.

6.5 It is suggested that all items of agricultural engineering industry are handled by one centralised technical agency in Ministries of Agriculture and Industrial Development. Ministry of Agriculture can have a Directorate-General of Agricultural Engineering with separate Departments for major items such as Tractors and Farm machinery, Irrigation Equipment (including Engines and Pump-sets), Hand operated and Bullock drawn implements, Small-scale industry and Processing Equipment. State Government set-ups can be organized on similar lines. In view of the size and importance of the industry, there should be a separate Development Council for the Agricultural Engineering Industry. Directorate General of Technical Development can have a cell specially equipped to serve the Agro-Processing industry.

7. Processing Industry

Processing of farm products is assuming greater significance. It is a sizeable industry. The industry is in the process of modernization. ISAE should equip itself with more date on the processing industry. ISAE has now appointed a sub-committee headed by Prof. A.C. Pandya to handle this aspect including assessment of demand and study of problems of the processing industry. This sub-committee will co-ordinate with the ISAE main committee on the Agricultural Engineering Industry (Chairman Mr. B.K.S. Jain).

8. Follow-up action

8.1 ISAE Standing Committee on Agricultural Engineering Industry, under the Chairmanship of Mr. B.K.S. Jain, will periodically review the problems of industry and take up suitable follow-up action on the recommendations made above. This may include meetings with Ministries and agencies concerned for better co-ordination and more effective follow-up.

8.2 All these recommendations were unanimously adopted by the General Body at the Plenary Session held on the 5th February, 1972.

Jabalpur.,	S.R. DIWANJI	B.K.S. JAIN
5th Feb., 1972.	Rapporteur	Chairman

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(Messrs. Manbahadur Gurung, A.M. Michael and Bala Krishna Shrestha are co-operating editors as before.)

CONTRIBUTORS WANTED

This publication, published twice a year, has an objective to promote Agricultural Mechanization in Asia as its title shows. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials, students, etc. not only in Asia but also in the whole world. To enrich contents and to reflect many opinions, we want contributors for "**Agricultural Mechanization in Asia**". Articles, comments, investigations, reports and so on will be received with open arms. If you hope to contribute, contact us without delay.

Report from Research Organization

AGRICULTURAL MECHANIZATION IN ISRAEL

Research, Development and Application

by Mordechai Nivon (Weinblum)

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Introduction

The Jewish pioneers from all over the world who arrived in Israel at the turn of the century to resettle the country, considered agriculture as the central pivot of the developing economy. For these early settlers, agriculture was more than a profession--it was a way of life, one which demanded intimate contact with the soil, self employment and strict observance of the ideals of simplicity and labour.

A complete lack of experience and tradition characterized these pioneers but this handicap was more than compensated by their readiness to accept new methods and admit novel ideas. It thus happened that agriculture in Israel side-stepped a protracted development stage and entered forthwith the modern era of agriculture.

Israel is a small stage, situated in a semi-arid zone. The two major economic factors of agriculture, land and water, are therefore severely restricted and, today, these resources are fully exploited. Any further development in production can only be extracted from the area already under cultivation with better utilization of the meagre water reserves.

A third essential factor, labour, is in constant decline. The rapid expansion of industry and services has caused a drift of the working force towards these employments with a consequently over increasing labour shortage in agriculture. The rural population is only 17.5% (out of total population of over 3 million) of whom only 50% are directly employed in agriculture.

The decrease in available labour was offset by the increased investment in labour-saving devices, tractors, mechanical equipment etc. This development, together with the limited land and water resources mentioned above, have created a very intensive type of irrigated farming, requiring relatively large amounts of water and manpower per land unit.

Israel farmers today supply about 75% of the country's food needs which is about the limit of items which can be produced locally. All additional produce is experted, a development which has gathered great impetus over the past ten years.

The principal agricultural products in Israel in 1971 and their relative land utilization and contribution to the total agricultural output are in **table 1.**

The Organizational Structure of Agricultural Settlement.

The particular type of settlement has a great effect on the extent and level of farm mechanization. There are three distinct types of farms in Israel : Kibbutzim (collective farms), Moshavim (cooperative small-holding settlements) and private farms.

Kibbutzim : A collective farm, owned and run by the members (anywhere between 100～1000), each one contributing according to his ability while all his needs are supplied by the community. Generally, the land allocated is about 500 hectares under irrigation and similar area under dry-farming, in accordance with the geographical position of the farm. The various branches and their relative size are determined

Table 1. Principal Agricultural Products in Israel in 1971

Product	% of total land under cultivation (411,000 hectare)	Value (% of total output)
Wheat	26.0	1.9
Barley	4.2	0.2
Sorghum	1.3	0.1
Ground nuts	1.5	1.1
Cotton	8.8	4.7
Sugarbeet	1.3	0.8
Vegetables	4.9	8.5
Melons and Watermelons	1.1	1.7
Potatoes	2.0	1.6
Citrus fruit	10.0	19.3
Other fruit	10.0	10.9
Milk (cow's)	—	9.3
Milk (sheep and goat's)	—	1.3
Beef	—	5.5
Mutton	—	1.4
Poultry	—	11.7
Eggs	—	8.6
Fish	1.0	2.3
Honey	—	0.2

according to modern scientific planning, aimed at maximizing profits with the limited resources available. The kibbutz usually specialises in a restricted number of branches or crops on a relatively large scale (50~300 hectares per crop). In this way it is possible to build up an expert staff for each of the main branches whose chief concern is the development and increasing efficiency of the branch. The large scale of the units makes modern technological methods, necessitating large investments, economically feasible.

In order to increase efficiency even more, the kibbutzim have organized themselves on a regional basis, mainly for postharvest processing and marketing. In these regional centers it is possible to find heavy earth-moving equipment, expensive harvesting machinery, garages and other service stations, where size has an obvious economic advantage.

Ideologically, the members believe in self-employment (as members of the collective) as the **sine qua non** of this type of settlement. To their minds, the establishment of a productive community is contingent on the members themselves running the enterprise without recourse to outside labour. On the other hand, there are many branches which at the existant development stage can only be run with the help of large crew, not always available in the kibbutz. The solution of these problems presents a special challenge to research in agricultural engineering.

Moshavim : Cooperative villages having up to 100 member families. Each family has 2~5 hectare of land and is free to plan the crops grown on the holding. A central village organization supplies essential services such as marketing, finance, education, etc., releasing the farmer from these cares.

In order to ensure a steady work table throughout the year, the individual farmer must grow a number of successive crops, the area of each crop being essentially small, between 0.2 and one hectare, making mechanization virtually impractical.

The small diversified plots make specialization, as practiced in the kibbutz, difficult and the acquisition of suitable equipment infeasible.

The Moshavim have also several regional organizations but with a more restricted scope than those of the kibbutzim. The principle of self-employment is also adhered to in many Moshavim, posing similar problems as in the Kibbutz; where observance is more lax, labour shortage defies solution. Several interesting ways have been tried of supplying mechanical equipment, through contractors, by pooling equipment on a cooperative basis, hiring out machinery from a central pool, etc. Apparently there is no single solution, but the different methods should be matched to the particular needs of each village.

Privately owned farms : Farming is also practiced on a non-cooperative basis on quite a large scale, with a great diversification in farm area and crops grown. On these farms hired labour is not an ideological problem but a practical one of finding suitable hands. Therefore also these farmers strive to mechanize as far as possible the various work processes. Cooperatives have been formed to supply this type of farm with certain services on a voluntary basis.

The state of farm mechanization in Israel today

The organizational structure of agriculture in Israel, described above, served as an impetus to the rapid mechanization of the various work processes. The development rate of mechanization can be seen in **table 2,** showing the number of tractors in use in Israel at different periods since the establishment of the State.

Table 2. The Increasing Use of Tractors in the Years 1948-1971

Year	No. of Tractors
1948	680
1949	1300
1952	3100
1956	4800
1958	5500
1961	7800
1963	9750
1965	11100
1968	14500
1971	19220

The distribution of the tractors by size categories at different periods also shows a definite tendency towards more powerful machines, which gives added significance to the numerical increase.

The increase in the number of other items of equipment, such as ploughs, cultivators, combine grain harvesters, balers, mowers, cotton pickers, sugarbeet harvesters show the growing rate of mechanization in all those processes whose mechanization was reasonably solved.

Examples of mechanization achievements in various crops

In several branches all the work operations are in fact mechanized, either with imported machinery or machinery adapted to the specific demands. In these branches the entire operations connected with the growing and harvesting of the crop require 1 ~3 labour days per dunam.(10 dunams = 1 hectare)

Grain Crops: The soil is prepared with heavy tractors (track or wheeled), seeding is performed with wide drills herbicides applied by airplane sprayers, the crop is harvested by sophisticated combine harvesters, transported in bulk to storage silos where the grains undergo cleaning and sorting processes with the most modern machinery.

Cotton: This very important, irrigated crop underwent a mechanical revolution since it was first introduced in the country in 1952. In the first years of cultivation the cotton was picked by hand, requiring 0.8 work days per hectare, whereas today, all the work operations are completely mechanized, a small team of 3~4 workers being able to run 500 hectare.

Peanuts: Today this crop is fully mechanized at every stage, with only 30 work days required per hectare. As little as 10 years ago, most of the operations were still performed by hand at a cost 120 work days per hectare. This crop is a good example of the valuable contribution of research to the mechanization and increasing efficiency of a branch of agriculture.

As recently as 1958 the Israeli farmer was still experimenting in an effort to find a suitable digger. In the collection of the bushes into heaps for drying a great deal of manual labour was expended. The dry bushes were later fed into the threshing machines with pitchforks, the peanuts were poured into sacks and loaded into lorries, without any mechanical aids.

Research and development projects, which included importing suitable machinery, developing installations and adapting equipment to local conditions, revolutionized all the working operations. Today there is dependable machinery for cutting the bushes and arranging them in windrows for drying. A harvester with a special pick-up device **(Fig. 1)** lifts the dry bushes from the windrows, threshes, sifts and transfers the crop to large bulk containers. The container, when full, is tipped into a waiting lorry. Thus a crop, which in the past was problematic because of its high labour costs, has become fully mechanized.

Similarily, machinery has been

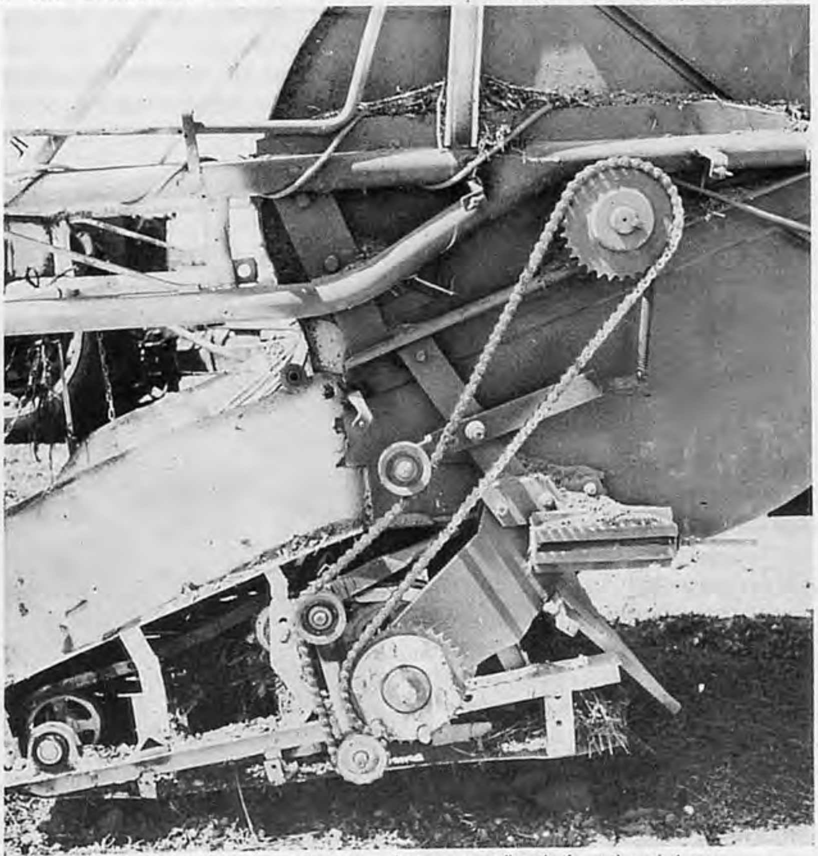


Fig. 1 Pick-up device for harvesting peanuts directly from the windrow

developed for other crops, such as potatoes, onions sugarbeet etc. However there are still very many crops where most of the operations are performed by hand, such as citrus and other fruit, celery, strawberries, tomatoes, flowers and others which require 100 and sometimes even 200 or more work days per hectare.

Research and Development in Agricultural Machinery

The aim of the research and development projects of agricultural machinery, as part of the overall agricultural research program, is to foster improved and more efficient production methods and to alleviate the severe shortage of suitable labour for these jobs. In this connection experiments were conducted to improve work methods, to introduce new ones and to adapt or develop machinery to operations so far done manually.

There are two academic research institutions dealing with these problems, the Institute of Agricultural Engineering of the Agricultural Research Organization, and the Station of Agricultural Engineering of theTechnion, The Israeli Institute of Technology, a research institute affiliated to the institute for higher learning, which trains and qualifies Agricultural Engineers.

There are about 80 engineers and other workers employed by the Institute of Agricultural Engineering, engaged on mechanization and engineering projects in 3 spheres: 1. Agricultural machinery--everything connected with the adaptation and development of equipment for sowing, harvesting, grading, packing, etc. 2. Environment engineering--everything connected with environment control systems of the crop or of the product after harvest until it is marketed, such as cooling and drying of the product, plant protection by spraying and dusting, interior climate of open and closed structures, etc. 3. Production and system engineering--increasing labour efficiency, improving organizational systems and the optimisation of various operations.

In conjunction with the research divisions there is a testing unit whose duty is to disseminate information to the farmer, importer and manufacturer on every new machine introduced or beginning to operate in Israel.

The Station for Agricultural Engineering of the Israeli Institute of Technology (Technion) provides the research framework for the staff or the Faculty of Agricultural Engineering in the fields of agricultural engineering, agricultural buildings or structures, irrigation and drainage.

In order to describe the type of research work undertaken in Israel we shall presens certain research projects of the major branches in progress at present, in more detail.

Harvest of Vegetables : Vegetables can be divided into three categories as regards potential mechanical harvest:

1. Vegetables suitable for once-over harvest, not too liable to mechanical damage, such as potatoes, onions, carrots, peas and beans for processing, etc.

2. Vegetables suitable for once-over harvesting but susceptible to mechanical damage, such as tomatoes and peppers for processing, celery, etc.

3. Vegetables requiring numerous successive harvests such as lettuce, strawberries, etc.

The first category vegetables are of course the most easily mechanized. Indeed, very many different types of machines have been developed over the world for harvesting these sorts of vegetables. It should here be mentioned that, on principle, the first stage in any research is an exhaustive enquiry into all the relevant knowledge and practice on the subject in existance throughout the world. In so far as equipment appears suitable it is imported and put on trial under various conditions. Generally the imported machinery is not suitable for growing and harvesting conditions in Israel without certain adaptations. Soil type, moisture contents of soil and soil texture at harvest time, inter-row spacing, ratio between foliage and fruit, all these factors have a decisive effect on the successful operation of a certain tool, probably designed for different conditions than those prevailing

Fig. 2 Onion harvester for small plots

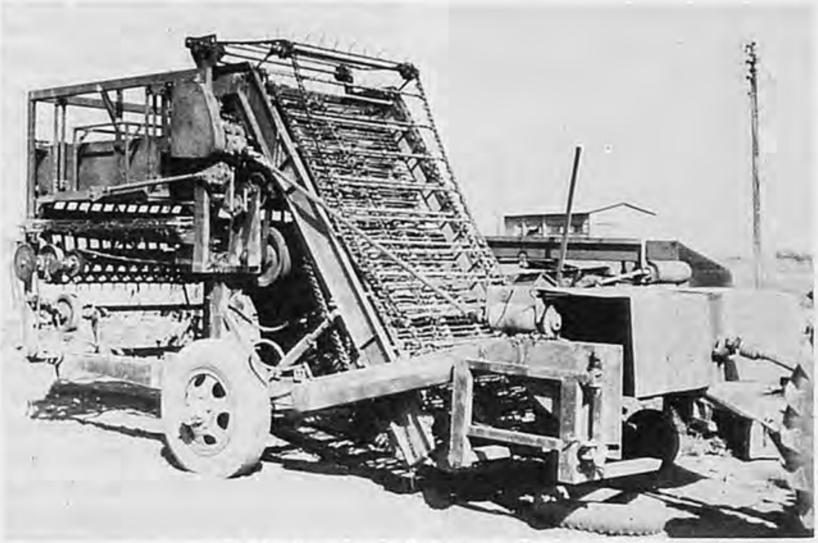


Fig. 3 A prototype of a harvester for pepper

in Israel. For example earth clods and soil which were lifted together with the potatoes in all the different types of machinery in use, threatened to clog up the grading and packing stations. A solution to this problem was found in very careful soil preparation before planting which obviated the formation of clods, by harvesting at the optimal date as regards soil condition and by developing devices for separating tubers from soil clods. In this way it was possible to utilize imported machinery even under Israeli conditions.

Original machinery is only developed after it has been proved that there is no possibility of utilizing imported equipment, since the development of original machinery is a costly process and, moreover, there is no guarantee of its successful implementation. Noteworthy in this connection is an onion harvester, adapted for operation in small fields, which was developed in Israel since no suitable harvester was found in other countries **(Fig. 2)**.

The second category of vegetables is more problematic. Here special breeding programs were introduced for producing varieties with concentrated yields, making harvesting more efficient. Pepper for the procession industries serves as an interesting example. This is a new, promising crop in Israel, the lack of manpower for harvest acting as a serious break on its further development. Only after all existing methods for harvesting peppers were examined and found unsuitable was the development of an original machine initiated. As a first stage in the research the principles of fruit abscission were examined. Plant breeding was directed towards weakening the tie between fruit and plant at harvest time. When it was found possible to separate the fruit from the plant by pressure as the plant passes between two rollers, and all the relevant design factors and specifications were established to the last detail, the first trial model was built and tested under field conditions (**Fig. 3**). The development of this machine is still in progress until the researchers will have designed a machine which can be manufactured on a commercial basis, capable of harvesting peppers of a standard which will satisfy the exacting demands of the dehydration industry.

The third category of vegetables poses the most difficult problems. Plant breeding has so far not succeeded in concentrating yields without a concomitant drastic reduction in yield. The products are highly susceptible to damage, making mechanization of the harvesting process virtually impossible and indeed in the whole world these vegetables are still picked by hand. Nevertheless, in order to facilitate these laborious tasks, an auxilliary device was developed in Israel, based on similar ones abroad. This is a self-propelled platform (mule train) which can be adjusted to advance at the same rate as the harvesting team progresses along the rows (**Fig. 4**). The harvesting containers are placed on this platform, releasing the harvesters from carrying containers and emptying them. The "mule train" can also provide shade and background music, increasing efficiency among the workers. Frequently the produce is graded and packed on the platform, reducing the time interval between harvesting and shipping and sparing the fruit unnecessary handling and transport before packing.

Fig. 4 Mule-train for picking tomatoes

The Israeli innovations on this "mule train" are its adaptation to various types of crops and farms and the installation of a cheap, quiet electric motor instead of the customary spark-ignition en-

Fig. 5 A prototype of collecting machine for pecan nuts

gine.

However, these types of crops still present a great challenge to plant breeders to achieve varieties for single harvests and to researchers in agricultural engineering to develop machines capable in some measure selective harvesting of fruit without damage to the crop.

Harvesting of Fruit: Fruit can also be divided into three categories with respect to the ease of harvesting them.

1. Hard fruit for single harvest such as pecan nuts, almonds, etc.
2. Soft fruit for single harvest.
3. Soft fruit requiring selective harvesting.

Very extensive research has been undertaken in the western world in connection with the development of machines and devices for fruit harvest but to date machinery has been successfully developed only for the first group. The most prominent device for harvesting these fruit is the shaker which grips the trunk or a central branch and vibrates it vigorously for several seconds. As a result of this action most of the fruit drop into a harvest container or into the groud. In the case where the fruit falls on the ground, specially prepared beforhand for this purpose, another machine is needed to collect the fruit from the ground and dispose it in containers. Here too, a machine imported from the USA for collecting pecan nuts from the ground was found unsuitable for harvesting under Israeli conditions in heavy soils as the ground is wet at harvest time. Again it was necessary to construct an original device capable of overcoming these obstacles which is at the moment at an advanced stage of development (**Fig. 5**).

Research throughout the world has not succeeded in obtaining a satisfactory solution for the harvesting of soft fruit. No method has as yet been found which will enable mechanical harvesting without causing considerable damage to the fruit. However, certain mobile auxilliary devices have been developed which facilitate fruit picking in tree tops, but the investment is high and the saving in manpower does not usually justify the outlay.

Consequently, citrus fruit, apples, pears, peaches and other soft fruit continue to be harvested by hand, 100 work days and more being required to pick 1 hectare.

Research has been initiated in Israel in an effort to find a solution to this problem. Certainly there is a long way to go until preliminary ideas which have suggested and the research undertaken will be consolidated into commercially workable solutions for the Israeli farmer.

It should be noted that the development projects are always accompanied by more basic research to foster better understanding of the mechanism which governs severance of fruit from stalk, the dynamic factors controlling abscission, etc., all of which will contribute to reaching better solutjons.

Grading and Packaging of Agricultural Produce

A considerable amount of research endeavour has been spent on the handling of the harvested agricultural produce. There are two aspects to this subject, the reduction of handling expenses by a saving in man hours in the various processes involved, and the improved appearance of the product. This includes treatments for prolonging shelf-life without a detrimental effect on taste and appearance, even after storage of several days or even weeks. This in turn will increase the profitability of the crop.

We shall here give two examples to illustrate the above:

Packing of Citrus Fruit : Citrus fruit is the largest agricultural branch in Israel, most of the fruit being destined for export to European countries. It follows that 4 weeks and more elapse between the harvest and sale of the fruit. There are more than 50 packing stations for citrus in Israel today, each one handling more than 10,000 ton annually.

Research on this subject continued for several years, aimed at developing methods and equipment for reducing the amount of manpower required and improving the appearance of the packed fruit. Installations were developed for the mechanical packaging of citrus by the "tight pack" method (**Fig. 6**). By this method a pre-determined number of fruit are poured into a container. The box is placed on a vibrating surface which forces the fruit to place itself in a tight pack arrangement. The box is then ready to be closed. This method is now being applied on a commercial basis. Additional devices have been developed for this system such as an optical grader, wrapping machine etc.

Another example of this type of research is in the waxing of melons. Special varieties of melons for export are grown in Israel. The melon fruit is highly susceptible, having a maximum keeping period of 4~5 days under ordinary conditions. This characteristic forced the farmers to send the melons to Europe by airfreight at a cost of more than $250 per ton.

A team which included physiologists, plant pathologists and engineers developed a waxing process and a special device which covers the melon with an appropriate layer of wax, creating conditions around the fruit which prolong its keeping quality for 10 days and more. Today, waxed melons are transported in refrigerated ships at a cost of only $70 per ton.

The examples given so far have pertained to specific branches. We shall now turn to examples of research of a more general nature, associated with very many different crops.

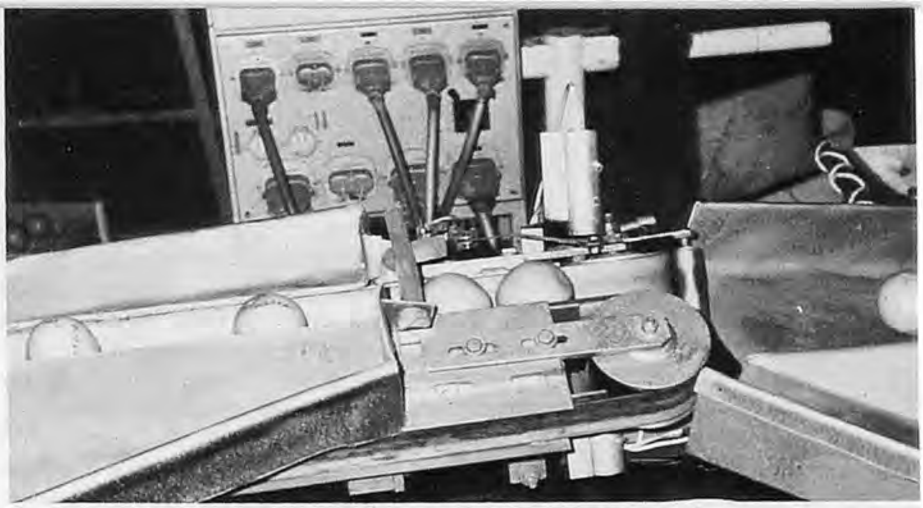


Fig. 6 A prototype for mechanical packer of citrus fruit

Soil Preparation : The soil is one of the factors which vary considerable between one country and the next and even in the same country there may be very great differences between regions.

There are two main objectives in the research undertaken in soil preparation. The one is determining the simplest and cheapest working processes which will yet give satisfactory crop results. The other aim is to produce implements suitable for local conditions, both mechanically and practically.

One of the chief dificulties encountered in this respect in Israel is the heavy, packed soil which must be turned into a fine tilth for seeding in a very short time. Many ploughs imported from Europe and the USA broke as soon as they were lowered into the soil. After ploughing there are still very many operations to be performed until a suitable seedbed is established.

Research must apply itself to all these problems and indeed there are several promising solutions.

Transport : It can wellbe stated that transport is important factor in the processes involved between harvest and marketing. The harvested produce must be brought from field to packing house. Within the packing house it is transferred from one handling station to another. From here it is transported to the wholesale market or, if destined for export, to the harbour or airport where a further Odyssey awaits it.

This subject is given considerable attention by research in view of its great economic importance. Multi-purpose methods for transport in bulk from field to packing station or gin have been developed in Israel, for use with a diversity of products. The principle is based on harvesting the product into large bulk containers: a special fork lift attached to a tractor can raise and transport the container to the packing house where it is lowered and the tractor is free to return to the field for the next container. This method obviates the unnecessary waiting time of the expensive tractor and enables extensive saving in transport equipment since the same equipment can be put to varied use. The extension of this method for use with transport of seeds, fertilizers, grain, cotton, has turned it into an interesting, multi-purpose method.

Plant Protection : The greater the development of a certain crop, giving higher yields of first quality produce, the more serious are the problems of disease and insect control, which, if ineffective, can cause heavy damage and yield losses. New expensive chemicals for plant protection constantly appear on the market. Millions of Dollars are invested each year in the large-scale application of poisonous substances for controlling pests and diseases. Apart from the burden of the expense, residues in the air on the produce are bound to be detrimental, one way or another, to the nation's health.

It is therefore of the utmost importance that ways and means be found for reducing the amount of poisonous chemicals applied and to prevent drift over distances. The equipment in use today does not alway meet the requirements of specific crops. Research undertaken in methods of application of plant protection chemicals in citrus orchards showed that although 15,000 liter of spray were given per hectare, there were many places on the tree where the spray did not reach at all, due the dense foliage. These places serve as a breeding place for insects and more frequent sprays are therefore called for.

A group of scientists is engaged in Israel on research in the engineering aspects of the varied equipment available in order to find methods and implements which will ensure effective control with a minimum of material.

System Engineering : Modern agriculture is a very complicated undertaking. One cannot deal with a single component without reference to the system as a whole. The mechanization of a certain process is linked to physiological, anatomical, pathological, economic, organizational and related problems. The earlier we examine every innovation in the context of the whole system the more effective will be the allocation of the research effort to the relevant problems. Consequently, a special team has been appointed, within the framework of the Institute of Agricultural Engineering, which deals with system engineering and operational research. The researchers analyse whole systems, from the soil preparation stage to marketing in an endeavour to discover the vulnerable points in which, from the point of view of the system, it is worthwhile to invest the greatest effort.

The system for growing flowers for export may serve as an example of the above. One thousand farmers grow flowers in green houses or, unprotected, in the field. The flowers must be picked daily during the season, tied into bunches and sent to the packing station where they are wrapped and placed into carton containers. From here they are sent to a central warehouse near the airport, allocated according to the prospective customer and flown to Europe. This is a very complicated system which must work both efficiently and reliably. The mechanization of any particular stage of harvesting, grading or packing is liable to affect the whole system. Consequently research was undertaken into the system as a whole to study its particular liabilities and to find optimum solutions for the entire system as well as for its various components. This research directs the specific research in each one of the different functions of the system: harvest, transport, grading, packing, allocation to customers, etc.

Extension Services : Regular and efficient instruction is the keystone to rapid professional advancement. Without an energetic extension service research findings will remain unapplied. Instruction must be intimately connected with research, advancing side by side in order to disseminate the newly established information as rapidly as possible amongst the farmers.

As the standard of mechanization rises, the need for greater specialization amongst the extension officers increases. In Israel extension services in farm machinery are supplied by the Extension and Professional Services of the Ministry of Agriculture, with a team of 25 officers active in all parts of the country. The instructors take advantage of the latest methods in mass media to supply information to the farmer, arranging demonstration days, field days, courses, radio and television programs and, of course, regular visits to the individual farmer, giving and encouragement.

Conclusion

Agriculture in Israel is one of the central pillars of the economy and the society and will remain so, in the opinion of the author, for many years to come. However, in the modern economy, the tendency is toward greater food production, with emphasis on variety and processed produce, ready for immediate consumption, without the time consuming labour for preparation by the housewife. These demands present agriculture with unprecedented technological challenges. The agriculture of the future will be mechanized and industrialized. Already today, there are in the world, including Israel, certain types of crops which are grown under completely controlled conditions, where all the climatological factors are automatically regulated by computers according to previously supplied data.

A similar tendency toward automation is evidenced by the animal husbandry branches. There are, for instance, many chicken houses in the world which are air-conditioned and where all the feeding and disposal of refuse is done without any manual labour.

However, side by side with these ultra-modern innovations, there are still very many crops which require hundreds and even thousands of work days per hectare and without any feasible, mechanical solution in sight.

The planners of agricultural policy in Israel had the foresight to establish a system of research and extension for all the different technological problems concerned, and in cooperation with the farmers, strive continuously to meet these challenges.

In future, more than today, a more penetrating understanding of the system as a whole as well as its components will be imperative, demanding close cooperation between engineers and specialists of other disciplines, in order to attain ever higher results.

The author believes that the knowledge which has accumulated in Israel can also serve other countries in the area, as their needs for agricultural mechanization will increase at a growing rate together with the social and industrial development. ■■

Research Activities in Institute of Agricultural Machinery

(I. A. M., JAPAN)

by Haruo Ezaki

Head of the 2nd Research Division. I.A.M.
Nisshin 1-40, Ohmiya, Saitama-Ken, Japan

1. Establishment of Institute of Agricultural Machinery

The history of research on agricultural machinery can be traced back about 50 years ago when the laboratory was first set up in National Agricultural Experiment Station, to start the development of human power and animal power implements, investigation of European and American agricultural machinery and extension work based on the utilization technics on machinery. In 1945, it grew up to one Division which consisted of seven labolatories, namely Research Division of Agricultural Machine and Tool.

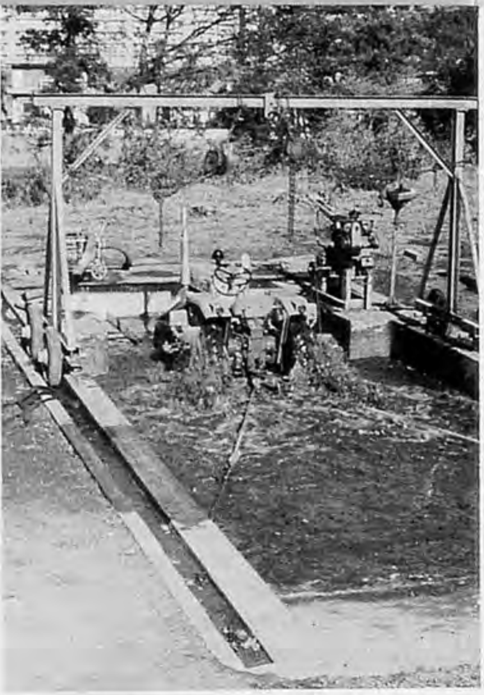
Though the average scale Japanese agricultural management is small, farmers are compelled to maintain steady management. Further progress of agricultural mechanization was then strongly demanded to cope with the remarkable development of Japan's economy.

In the meantime, the activities of the division were enough to keep pace with demand, I.A.M. (Institute of Agricultural Machinery) was established, jointly contributed by the Japanese Government and private enterprises on the basis of the revised "Agricultural Mechanization Promotion Law" in 1962. This Institute is composed of three research divisions (T. Miura, H.Ezaki, K.Ogawa) one testing division (O.Ariyoshi) and general affairs division and survey (K.Wazaki) and information section.

2. Organization and activities under I.A.M.

I.A.M. is located at Nisshin 1-40, Omiya, Saitama Pref., 30km away from Tokyo to the north-east. Laboratory buildings and facilities are arranged in good order in the area of approx. 18.5 ha surrounded by fine circumstances. Beside this main area, there is an attached farm of approx. 16 ha in Kawasato, where field test are conducted.

Main building of I.A.M.



Water and dust proof test of tractor

Board staff are four directors, four advisors and one auditor under chief director (Motoi Tachikawa). The research projects and activities are discussed and approved by Operation Council.

General affairs division which consists of general affairs section and accounting section is concerned with managerial work. A research secretary and survey and information section are responsible for collecting informations on agricultural mechanization concerned from home and foreign countries, and survey work in general.

There are three research divisions and each of them holds 12 to 20 researchers. They are organized by research project with 3 to 5 researchers, engaging in development and research on their respective agricultural machinery.

The research divisions are concerned with

(1) Engine, tractor and tillage machinery

(2) Seeding and fertilizing machinery

(3) Pest control machinery

(4) Irrigation and drainage machinery

(5) Transplanting machinery

(6) Harvesting machinery

(7) Drying, storage, processing machinery

(8) Fodder crop machinery

(9) Feed processing machinery

(10) Livestock raising

(11) Fruits machinery

(12) Vegetable and commercial crop machinery

(13) Research on safety for farm machinery

One testing division with 15 members conducts OECD test and National & I.A.M. test.

One workshop with 5 member manufactures measuring instruments, experimental apparatus, modified machines and repairing work.

The attached farm provides rice, wheat, vegetables fields and pasturage for development and testing of agr. machinery.

3. The objectives, techniques and the scales of operation of research project.

1) Research on tractor and tillage machinery

a) To predict the trafficability of tractor on wet field, tractor performance are analyzing and the relation between soil and wheels is defined. Running gears for tractor, rice transplanter and small combine were developed. To improve the durability of tractor, the characteristics of torque variation were measured. The testing apparatus for measuring durability of tractor was made and tried for some tractors. Levee forming machine, trencher and leveller for small tractor were developed.

b) In respect to the decrease in agricultural population and bigger farm management with small number of farmers, we have just started to develop operatorless tractor and its tillage machinery with perfect safety and better quality of work.

c) Tractor used for ordinary field can't work on slopes over 12° from a view point of safety and precision of work. But a orchard and grassland are mainly on slopes over 12°. To meet such situation, tractor for hilly land is being developed.

2) Research on pest control machinery

a) The objective is to aim at saving larbor for spraying and dusting operations with high efficient machinery.

The pipe duster with its pipe 30 to 50 meter long was developed and practically used. This duster requires two operators, who walks on adjacent levees without entering into the field.

The mounted type granule ap-

Field test of prototype rice transplanter

Testing the binder (Japanese type)

Test of discharge rate of dust from the pipe of travelling power duster

plicator was developed and is practically used.

Ultra-volume application kit for helicopter was also developed.

b) The pest control machinery and operation methods are developed so that effective but poisonous chemicals do not affect farmers' health.

Agricultural chemicals tend to change from liquid to granule. Thereby pest control machinery that can perform efficient and uniform application is developed.

c) We embarked in imporvement and research on knapsack type sprayer as a ultra low volume application kit to spray chemical efficiently on vegetable field and orchard where water service is inconvenient. In addition improvement and research on mist blower for apple orchard under way. Furthermore as biological protection we improve an applicator with which we can spray virus (Adoxophyes Privatara) with little amount of culture liquid.

3) Research on seeding and fertilizing

a) In Japan, 99% of the paddy field is transplanted, due to traditionally stable yield. However, shortage of labor and increase in labor wage brought about the development of direct seeders for wet field and dry field, along with the improvement of direct seeding cultivation.

b) To improve quality of work for direct seeders and fertilizer applicators, research on automation to detect the uniformity of seeds (or fertilizer) discharged has been started.

Birds scarer is developed to prevent the birds from damage.

4) Research on transplanting machinery

a) It requires hand labor 80 hrs. to plucking seedlings from nursery bed 120 hrs. per one hectare, altogether 200 to 220 hrs., which accounts for nearly 1/3 of the labor input for rice cultivation. This situation and labor shortage give an impetus to the development of transplanters. 2-row transplanter developed for young seedlings (2 to 3 leaves old) reared in a nursery box can transplant one hectare in 15 to 20 hrs. including 40 to 80 hrs. for plucking seedlings and reduce transplanting labor remarkably.

b) In order to improve the efficiency, 4 to 8 row transplanters are developed and improved for 2 to 3 leaves (old) seedlings.

To obtain stable growth of seedlings, transplanters for seedling older than 4 leaves is developed, with special emphasis on quality of work.

c) Since rice transplanting in a season of high humidity and high temperature is one of most arduous farming tasks. In this connection, transplanters with automatic controls are now being developed.

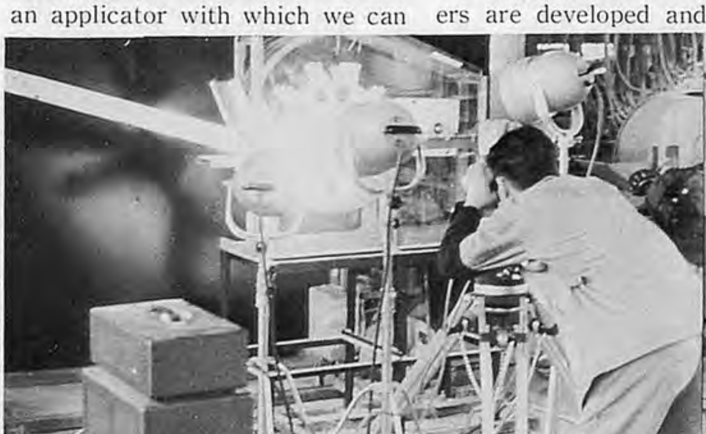
5) Research on harvesting machinery

a) The objective is to develop harvesting machinery suitable for the conditions typical of small scale paddy field in Japan, where majority of rice plants is hard to thresh and height of plants ranges 0.8 to 1.2m.

As imported combines were not suited to our conditions, research was directed towards reduction of loss and damages.

To develop more efficient combines more suitable to our conditions, analytical research was conducted on pregathering unit, cutting unit, and threshing unit. As a result small binder with cutting width 30 to 70 cm was developed and 600,000 sets were diffused, while small combine with cutting width 50 to 80 cm was developed and 100,000 sets were diffused,

b) Such a small combine shows a better quality of work for high-moistened, hard-to-thresh varieties, although its efficiency is a little smaller. High efficient



Analysing of threshing mechanism by fast motion camera

Temperature regulation test for vertical dryer combine with cutting with 1m, throughput 2t/hr., loss less than 3% and damage less than 0.5% is our aim.

Research on automation of harvesting has started to cope with labor saving, safety and improvement of quality of work.

c) In respect to harvesting paddy rice and wheat, Japanese type combine, namely head feeding combine was developed with high efficiency and high accuracy. Besides the mechanization of rice and wheat, harvesting machinery for cereals such as beans, corns are on the way of development.

d) Prototype small type suger cane harvester was almost completed and they are now on the field test.

6) Research on drying, storage and processing machinery

a) In Japan, drying, storage and processing is greatly influenced by the transition of rice distribution pattern and change of harvesting methods. Accordingly research is focused on analysis of various technical problems in correspondence with various situations. Batch type and heated air circulating dryers were developed and 1,500,000 sets are now on farms. Research on interrelationship among drying conditions, damage to grain and deterioration is conducted to aim at establishing cheap drying and storage method.

b) Paddy moisture tester is developed to find out momentary moisture content of circulating paddy in a dryer. This contributes the improvement of quality of rice.

Ultra-high speed drying method is developed.

Automation and systemization of harvesting, drying and processing are encouraged.

7) Research on forage production and processing machinery

a) In Japan the number of milk cow and beef cattles amounted increasingly to 3,615,000 heads in 1971. To correspond with such situation forage area amounted to about 660 thousand hectares. Japan is now dependent on large hay making machinery imported from Europe and U.S. As harvesting season is subject to bad weather, machinery is now being developed free from bad weather.

b) To rationalize domestic circulation or marketing of feed, research on profitable feed pelleting machine in transportaion, storage and feeding is now under way.

c) Research on chopping type forage harvester, cutter and small silo to produce silage is now going on.

8) Research on livestock raising

a) For labour saving and rationalizing of raising in dairy farming, poultry raising and pig raising. Research on forage drying-storing machine, dryer for feed pelleting machine, feed discharging machine, feed distributing waggon and waste disposal equipment.

b) Research on warning device for milking-out, measuring device of milk and milk conveying equipment is now under way, to automatize milking.

9) Research on Fruits Machinery

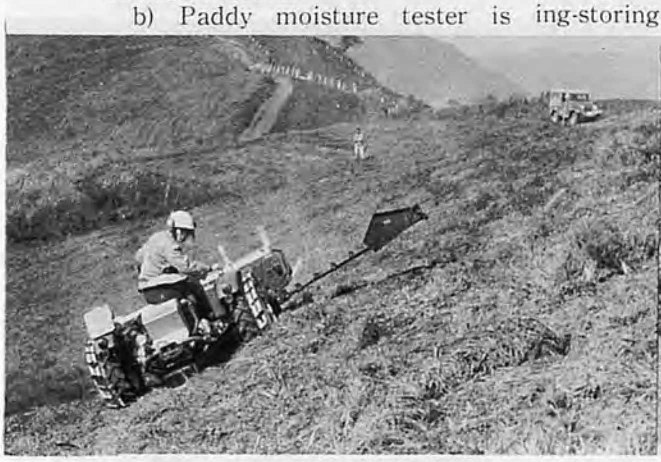
a) Portable or self-propelled vibrating harvester and catching frame are manufactured for test and they are applied for harvesting plum, chestnut, apple and mandarin orange, etc. At present time they are put to practical use for plum harvesting.

b) Research on a vehicle for apple and mandarin orange harvesting on hillsides and picking-up machine of chestnut are being developed.

c) As regards mandarin orange storage, research rationalization design of storage equipment, its efficient utilization and labour saving method in respect to management is proceeded.

10) Research on Vegetables Machinery

a) Up to this time vegetable culture has not scarecely mechanized. Farmers relied on mainly human power. However it is recently becoming possible to integrate vegetable growing areas and to introduce mechanization. Research on self-propelled machines such as transplanter, thinner and harvester are steadily



Field test of feed processing machinery

Testing prototype tree crop harvester

towards development.

b) In Japan vegetables culture in green house is getting popular. Research on heater, soil steriliz er, conveying cart, pest control machine in a green house is being gradually developed.

11) Research on safety of agricultural machinery operations

a) As agricultural machinery increases in number, operator's comfort, accidents and physical disability caused, by the machinery become problems which should be studied based on human engineering.

b) By analizing of strength applied on tractor safety cab and dynamics of overturned tractor, principle of tractor design is established.

Operator seat is redesigned from the human engineering point of view, as tractors of Japanese make are small and compact in size.

As vibration of agricultural machinery often causes operator's physical troubles, research is started on analysis of vibration and prevention of vibration.

c) As dust or trash affects the operator's health in the farm structure such as paddy drying facilities, outbreak of dust is investigated and the measure to avoid dust is developed.

4. Testing

The testing division conducts OECD test and National & I.A.M. test. The last test is conducted by request of manufacturers and farmers.

The machines put to those tests in 1970 and their numbers are as follows; 9 riding type tractors, 13 walking type tractors, 2 power sprayers, 13 small binders, 2 engines, 5 small combines and 2 large combines.

And in 1971; 7 riding type tractors, 4 power sprayers, 3 power dusters 7 binders, 8 small combines, 5 transplanters, 4 fertilizers, 11 rubber rolls, and 16 other machines.

5. Educational and training activity

With regards to educational and training activities, there is no division in charge. However we accept postgraduated or qualified researchers and give them training within the period of one year.

Extension service to farmers and training of foreign trainees are conducted in other organizations.

6. Other organizations

Japan is devided into eight agricultural regions. And in each region, they have a national agricultural experiment station, in which there is one or are two agricultural mechanization laboratories. The main raesearch projects of those laboratories are on the mechanization suited to the agricultural conditions typical of each region, such as rational combination or selection of the machinery and economical utilization of the machinery based on farm management.

Besides those national agricultural experiment stations, there are 46 prefectural agricultural experiment stations. Each station has its own agricultural mechanization section which contributes to the farmers on a prefectural basis in connection with farm mechanization.

There are 32 universities and colleges which have agricultural machinery laboratories. Each laboratory has one to three professor(s), and is concerned with education and research. ■ ■

ADVERTISERS' INDEX

Report from Research Organization

New Agricultural Equipment from The International Rice Research Institute

by Amir U. Khan

The Head, Agricultural Engineering Department, IRRI, and Project Leader, USAID/IRRI Agricultural Machinery Development Contract (Manila, Philippines)

The South and Southeast Asian countries are characterized by small farm holdings, low farm incomes, and low labor costs. Developments sparked by the so-called Green Revolution have created conditions which are conductive to the mechanization of tropical agriculture. Past attempts to mechanize tropical agriculture with imported equipment from the industrialized countries have met with limited success.

There are two distinct agricultural mechanization technologies that have evolved in the world to suit two sets of agro-economic and socio-industrial conditions. The western approach is based on largescale dryland farming with high-powered equipment. It Places major emphasis on reducing labor. Mechanization in Japan has not followed the western approach. Rice is a major crop in Japan which is grown under wetland conditions on small farm holdings. The high price support of rice, rapid industrialization and a widespread practice of parttime farming has helped to mechanize Japanese agriculture with small but highly sophisticated farm equipment. In spite of a high degree of mechanization in Japan, labor utilization for paddy cultivation remains high. Japanese farm equipment, however, is too complex and often uneconomic for the tropical Asian farmers. Paddy transplanting machines, reaper binders and harvester combines, which have gained widespread popularity in Japan, are excellent examples of functionally suitable but economically unacceptable machines for the tropical regions.

The inadequacy of the available technologies from the industrialized countries to satisfactorily meet the overall requirements of the tropical regions has been a bottleneck to the mechanization of agriculture. Recent

· The International Rice Research Institute is engaged in the development of suitable farm equipment for tropical agriculture under a research contract with the U. S. Agency for International Development.

TABLE THRESHER: The machine has a flat circular threshing surface with an integral fan on its underside. It is powered by a 3.0 hp air-cooled engine. It can thresh dry or freshly harvested high-moisture paddy. Four to five men can thresh about 350 kg of paddy per hour. The machine is commercially produced in the Philippines.

SINGLE HOPPER PADDY SEEDER: This machine can sow pregerminated paddy in rows on puddled soils. Five to seven hours are required to seed one hectare. The machine has a single wheel to facilitate transport on narrow field levees and to provide the motive power for the metering mechanism. It is commercially produced and sold for about US$45.00 in the Philippines.

developments in the industrialized countries reflect a widening gap between the available mechanization technologies and the needs of the farming communities in the LDC. These developments will, no doubt, further hamper agricultural mechanization in the tropical regions. It seems reasonable to contend that to mechanize tropical agriculture, new technology compatible with the agricultural, social, economic, and industrial conditions of the tropics should be developed.

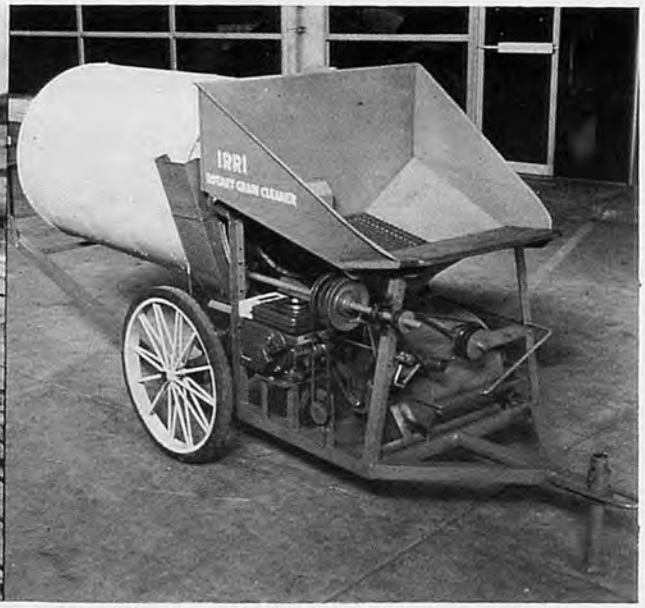
For a variety of reasons, the development of equipment for the production and processing of rice in the tropics has received little attention. The Institute considers that widespread mechanization of tropical agriculture is only possible through the development and indigenous production of suitable equipment within the region. The establishment of an indigenous farm equipment industry in the tropical region seems a prerequisite for the successful mechanization of agriculture. The existing farm equipment industry in the less developed regions has neither the money nor the know-how to develop new technology. Under the circumstances, public research institutions in the region must provide leadership by developing suitable farm equipment which could be manufactured with the available production methods in Asia.

The International Rice Research Institute is attempting to develop an appropriate rice mechanization technology with the development of simple agricultural equipment to suit the manufacturing capabilities of the LDC. This program is primarily focused towards the requirements of the 2-to 10-hectare tropical farms which are too large to work with animals and uneconomic to work with the farm equipment originating from the industrialized countries. Technology to dry and process paddy in large centralized plants is readily available from the industrialized countries. The department's program in this area is, therefore, directed towards the development of simple drying and processing systems for farm and village level operations.

The Institute is, however, aware of the role that the farm equipment manufacturers from the industrialized countries can play mechanizing tropical agriculture. Continuing efforts are therefore made to encourage these manufacturers in developing special equipment for tropical agriculture. Every assistance is provided in testing and evaluating their prototype and newly introduced equipment.

Some of the machinery developed at the Institute are shown in the accompanying illustrations. A number of these machines are now in commercial production in Asia.

MULTIHOPPER PADDY SEEDER: This is a low-profile seeder with six independent hoppers for seeding pregerminated paddy on puddled soils. No cut-off mechanism is used to meter the seeds which minimizes damage to the sprouted seed. The machine has been released for commercial production in the Philippines and is expected to sell for US$40.00.

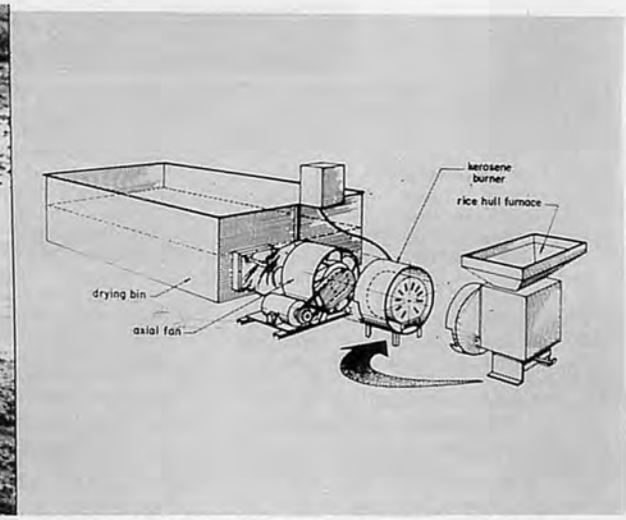


POWER GRAIN CLEANER: Dirty grain is screened first for large and small impurities in two concentric rotary screens. The screened grain is then tumbled as it moves through an airstream in a counterflow direction to remove lighter impurities. Output of up to 3 tons per hour has been obtained with the cleaner. The machine is commercially available in the Philippines.

STRIPPER HARVESTER: This four-row machine can harvest paddy in the field without cutting plants. Since straw is not handled through the machine, it is light and compact. Combined scattered and unthreshed grain losses of only 1.5 percent have been obtained in some tests with this stripping principle in a laboratory machine. Further development work is underway.

TRACTOR PTO THRESHER: This machine has been developed for custom threshing of rice and other grain crops in Asia. It can thresh dry as well as freshly harvested crop. The thresher is mounted on a tractor three-point linkage and is light enough for lifting with standard hydraulic systems. This feature provides easy field maneuverability. Threshing output of 1.5 tons per hour has been obtained.

SIMPLE POWER TILLER: This simple 4-6 hp power tiller is designed for fabrication in the Asian countries by small workshops. It has a sealed oil-bath chain transmission. Different attachments for dry and wetland cultivation have been developed. The machine has been released for production in the Philippines. It is expected to sell for less than one-half the price of comparable imported power tillers in the Philippines.



RICE HULL OIL FIRED BATCH DRIER: A simple batch type drying system is being developed for the Asian farmers. The system will have interchangeable furnace for oil, rice hull, or LPG and other fuels. The rice hull furnace has a 9-in, square combustion chamber with louvered walls on all sides. Air is sucked through the louvers which results in multi-layered combustion and a compact design. Further development is continuing.

HEATED-SAND CONDUCTION DRIER-PARBOILER: This machine is being developed to meet the drying and parboiling requirements at the village and farm level. The unit mixes wet paddy with heated sand in a drying-parboiling chamber for about 20 seconds and then automatically separates them. Sand is returned to a heating pan and is recycled through the drying-parboiling chamber. The continuous-flow machine can remove 12 percent moisture in a 20-second grain-sand exposure. If sufficient moisture is initially present in the paddy grain, starch granules are gelatinized and a parboiling effect is obtained.

LOW-LIFT BELLOWS PUMP: This simple pump is designed for lifting water through 1 to 1.5 meter heads. The pump delivers 50 to 80 gal/min at 1-meter head. The pump uses two canvas bellows with metal reinforcements. Each bellow has an inlet and exhaust flap valve. The pump is placed in the water source. The operator transfers his weight from one footrest to the other and water is alternately sucked and pumped by the bellows. The machine has been released for manufacture and is expected to be marketed at about US$40.00 in the Philippines.

BACK NUMBERS

Providing the World with MORE FOOD & EMPLOYMENT

Guide Book for Small Rural Cottage Industry & Rice Cultivation

This guide catalogued several hundreds tools, all manufactured or distributed by "CeCoCo" (Central Commercial Co.) and all applicable to what they term "cottage industry", "CeCoCo" editors spell out the small scale cottage industry concept: Small Scale Cottage Industry belies its name by providing a large proportion of all industrial employment and accounting for the great majority of all industrial establishment. However, it is often asked whether such industry can survice and perform a useful function in highly industrialized regions of the world, and what its place should be in the economic plans of developing countries. Analysis of the exact nature of the problems facing small scale industry and of the way in which it is adapting itself to meet them. Far from being moribound, **small scale industry is a dynamic force** with a valuable role to **play in the modern economy of both highly industrialized** regions and developing countries. In almost all developing countries in the world, there are determined efforts to achieve material economic progress and emphasis is being carried out to induce a shift in the structural pattern of the economy from one basically agricultural to one that is agro-industrial incharacter to assure an increasing level of **national production** within the framework of economic and social stabililty which does not require much of foreign exchange to insure its growth. That is very important to select such industries which **do not need foreign exchange in obtaining raw materials.** The high cost of living in the urban areas: nevertheless reduces the work's real income. Money incomes in the rural areas is lower than those in cities but the cost of living is equally lower compared with urban living. The full employment of cottage industry in the rural areas, can **provide additional forms of incomes on the part of rural families,** wich coud **reduce the influx of population to cities in quest for employment.** This ultimately would minimize social problem in urban centers.

The tools listed in this catalog are absolutely fascinating. One spends hours studying specifications, diagrams and photos of CeCoCo "making" machine. (In the Wire Products Section, for instance, one finds Paper Pin Making Machine, Staple Pin Making Machine, Gem Clip Making Machine, Hair Pin Making Machine, Safety Pin Making Machines, Nail Making Machine, Ham & Sausage Making Machines, Chalk and Candle Making Machines and Soap Making Machine, Mosquito Coil Making Plant, Rice Wheat, Corn, Bean, Coconut, Coffee, Bamboo, Rattern, Peanut Processing Machines, Waste Material Utilizing Machine, Saw-dust Briquette Solid Fuel Making Machine, Charcoal Making Kiln, .Fresh Coconut Oil Expelling Unit, Grass & Koral Mat Making Machine, Polypropylene or Polyethylene Twine and Rope Making Machine, Coconut & Banana Fiber Twine & Rope Making Machine, Automatic Motorless Pump, Hand Pump, etc.)

"CeCoCo" was established in 1916, but refers to an association with a manufacturer of **manual-type and animal-drawn farming implements** since 1863. They maintain "CeCoCo" **Exhibition and Demonstration Center** at Ibaraki City, Osaka Prefecture, Japan, only 20 minute by car from Osaka City. On the back cover of their guide book one sees photos of **dignitaries from all countries** of the world visiting "CeCoCo" Center. Some of the diesel and kerosene driven farm implements, and manually operated equipment proved to be especially pertinent to this reviewer.

Commented and reviewed by Mr. Ken Kern of "Whole Earth Catalog" 558 Santa Cruz, Menlo Park, Cal., U.S.A.

The 7th and 8th edition "Guide Book for Rural Cottage and Small and Medium Scale Industries" with valuable bulletins, sent upon the receipt of the International Postal Money Order for U.S.$100.00 or £4.00 Air mail Post paid.

"CECOCO" SMALL INDUSTRIAL & AGRICULTURAL CENTER in JAPAN

(Central Commercial Company)

P.O. Box 8, Ibaraki, Osaka 567, JAPAN

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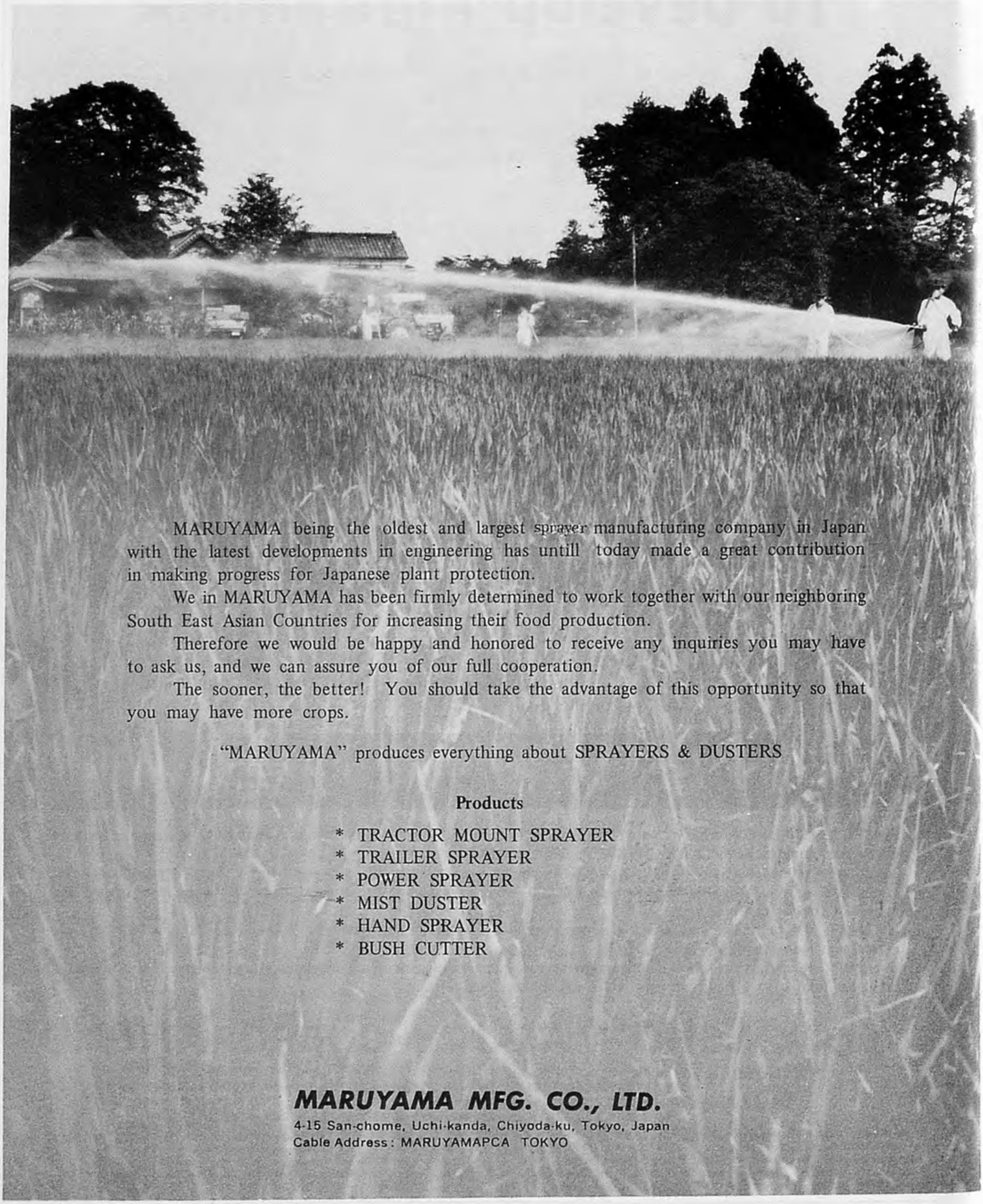

based on over 70 years of manufacturing experience and efficient usage in 70 countries around the world. Satake has successfully applied the most advanced rice milling techniques to meet all requirements for higher performance and lower cost. They are also compact so they occupy less installation space.

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3. Sturdy construction and durable parts.
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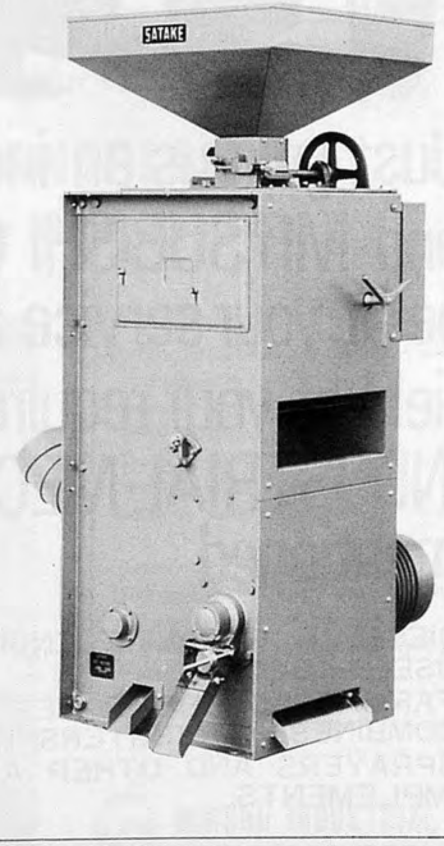
Capacity: 700 – 750 kg per hr. (paddy)
Required Power: 10 – 15 H.P.
Dimensions: L686 x W725 x H1,591(mm)



For more about MILLTOP advantages, write Satake immediately.

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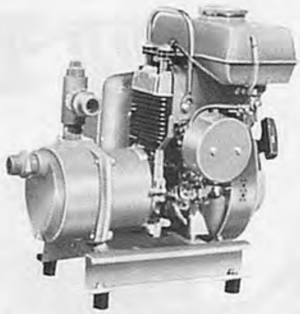

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IFM NewsLetter

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

Dear friends

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

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

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

Whenever you need more informations, please write me./

Yours Sincerely
Yoshikuni Kishida
Head of Directors

creates profit

Marketing

ISEKI has succeeded in establishing a remarkable distribution system throughout Japan. This not only provides for the organized distribution of our products, but also includes a farm management and technical guidance service for our users and dealers as well. Apart from supplying other Asian countries with agricultural equipment, ISEKI also provides them with assistance in establishing their own distribution systems. Ones which fit their respective economic conditions.

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ISEKI provides, on request, a complete engineering service, which includes training, planning and consulting necessary for agricultural mechanization.
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ISEKI brings more efficiency to your farms.

Easy adaptability to climate and smart appearance for pleasant operation. This is ISEKI's machines.

Each of ISEKI products undergoes thorough inspection, durability and performance tests, and exacting quality control. Further, ISEKI is proud of the establishment of its integrated system of paddy farming, i.e. planting through harvesting. Its operation follows briefly:

Tilling and puddling	:	By tiller and 4-wheel tractor
Planting	:	By rice planter
Harvesting	:	By combine harvester or reaper binder
Preservation	:	By automatic thresher, automatic rice huller, grain dryer and huller/polisher

Surely, you can choose any of the machines with your request.

ISEKI Power Tillers

Model AC1

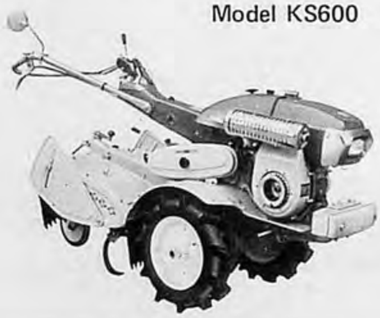
Model KS280

Model KC2 & 2F

Model KC4 & 4F

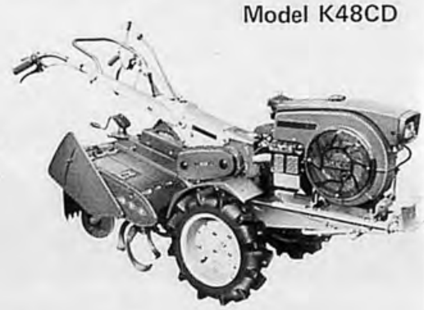
Model KS500

Model KS600



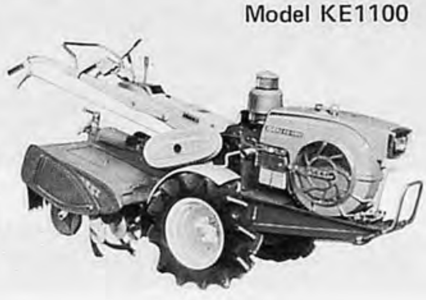
Model KL781D

Model K48CD



Model KE900

Model KE1100



ISEKI 4-Wheel Tractors

ISEKI

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Model TM1200

Model TB1700

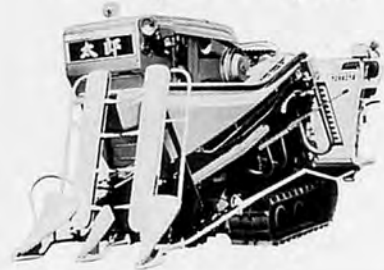
Model TS2000

Model TS2400

ISEKI Combine Harvesters

(Small type)

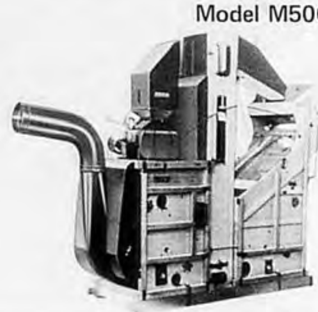
Riding type & walking type



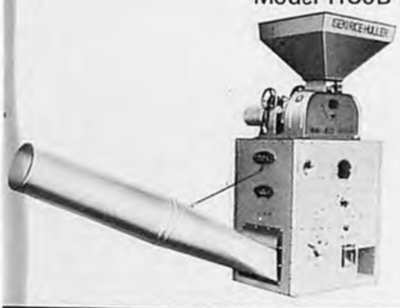
ISEKI Automatic Threshers & Hullers

Model D2L

Model M50CA

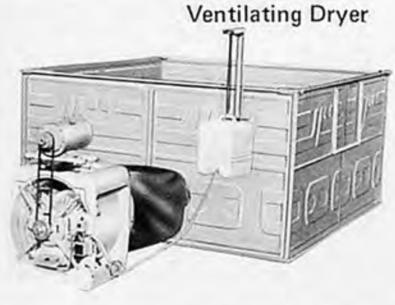


Model HC6B



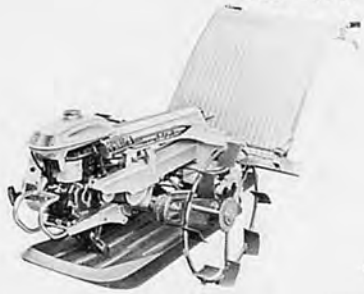
Others

Ventilating Dryer



Rice Polisher

Rice Planter



RS250 & RS500

r or reaper

r, automatic

r and huller

with your

del KS280

el KS500

el K48CD