International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL.X,NO.4,AUTUMN 1979

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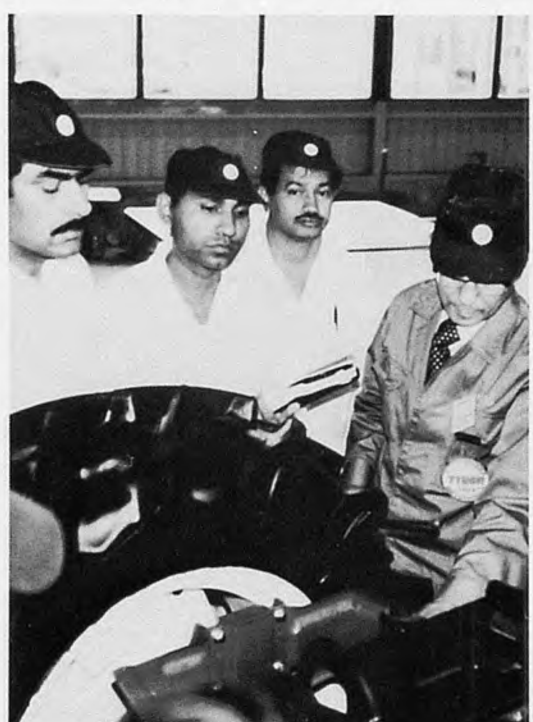

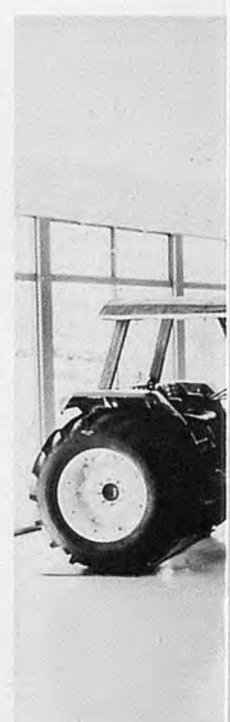

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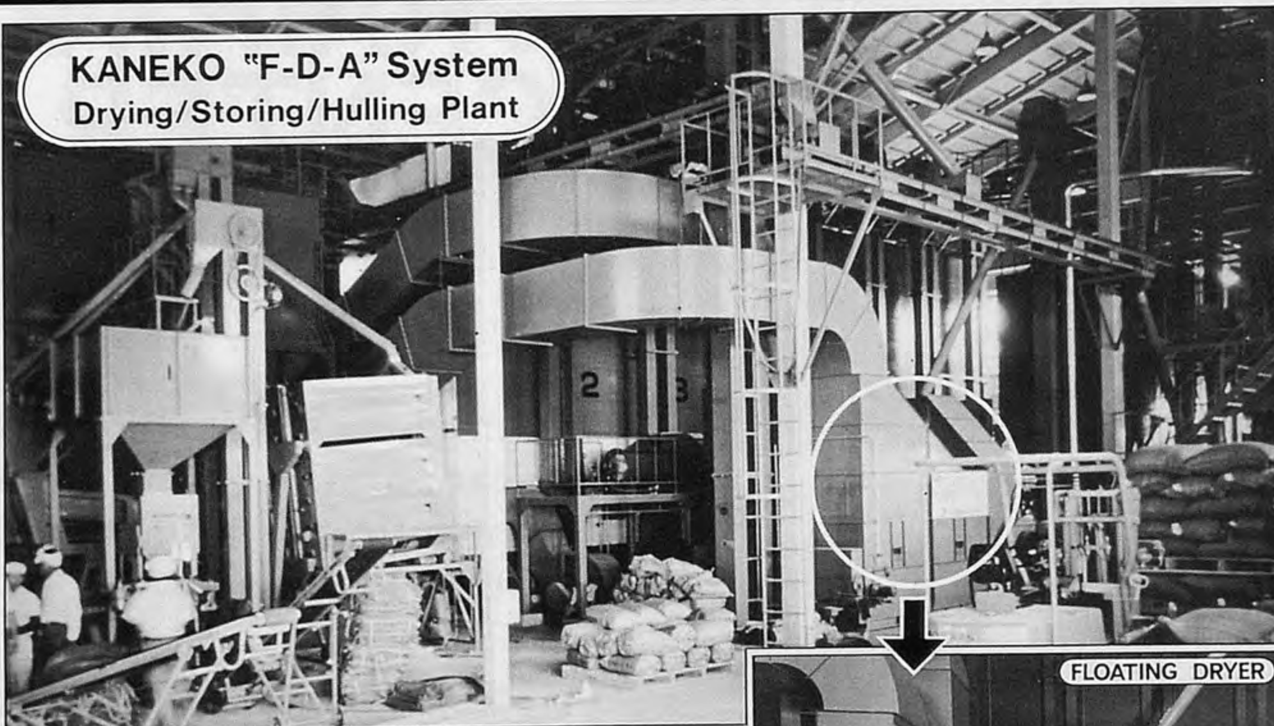

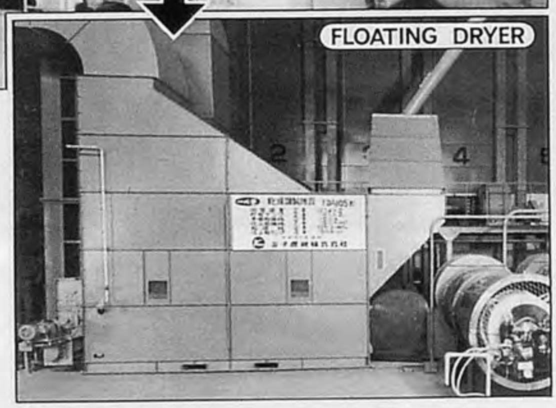

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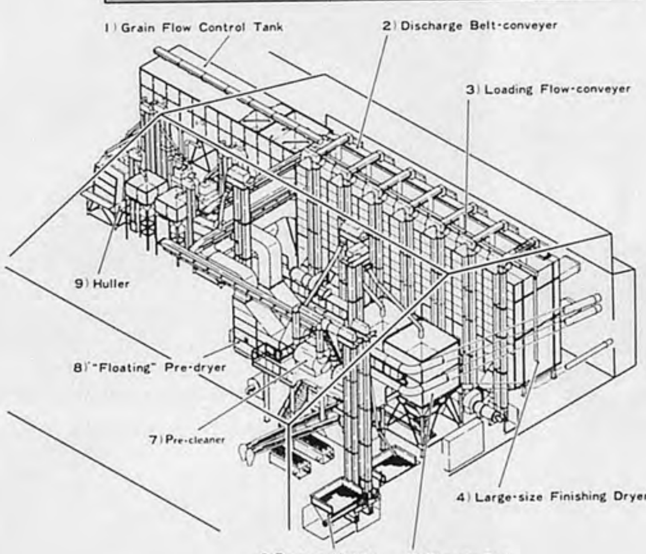

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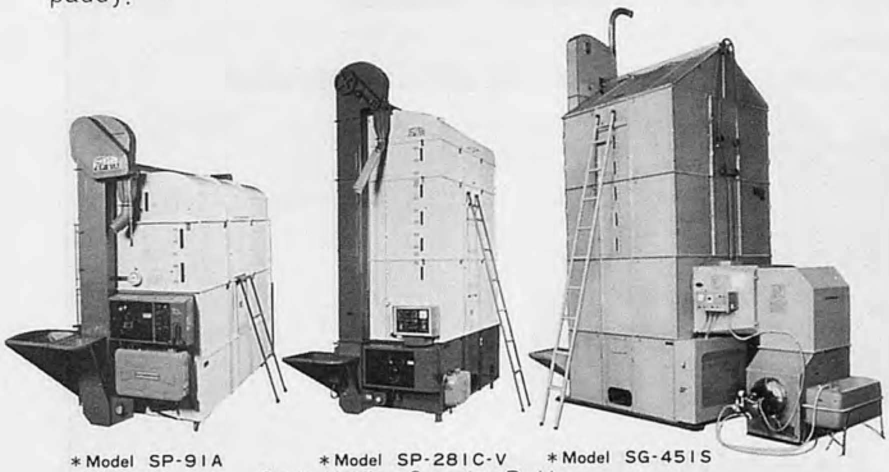

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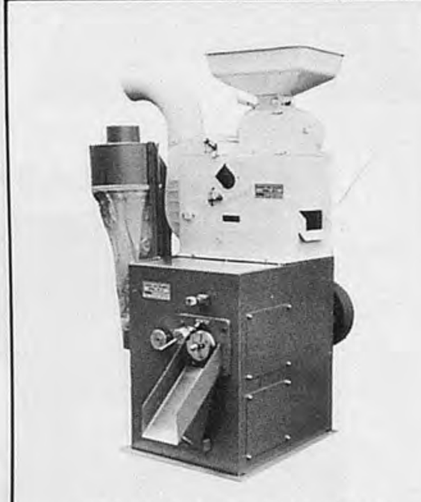

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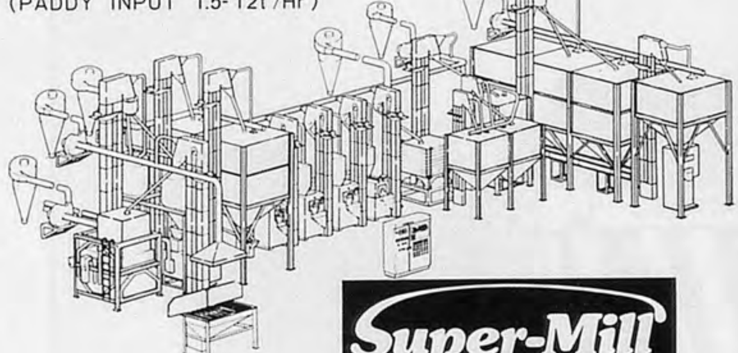

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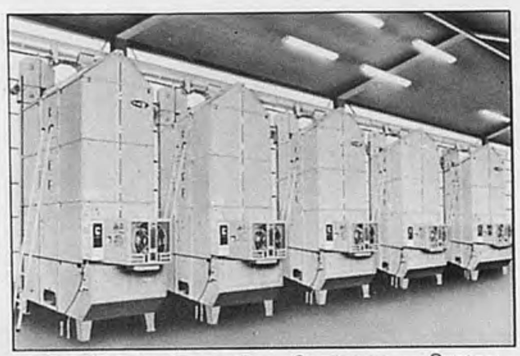

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Editorial

Agricultural Mechanization: In Need of Fresh Approach?

Over the years and in many countries, developed or developing, the advocates of agricultural mechanization never cease discussing the issues and problems of adopting mechanized farming in the developing countries. Scholars and scientists are no less persistent in conducting researches on the subject and publishing the results in various media. The AMA, for one, has since 1971 been concerned in promoting the subject. Enterprising businessmen and engineers do not lag either in investing sizable amounts of money and technology in the manufacture of farm machineries.

When these conditions are examined in the light of current development, the interest of those persons to "dig" deeper into agricultural mechanization suggests two possible meanings: i) It is an indication that remarkable progress has already been achieved; and ii) It is time to take stock of the issues and approach the problems of farm mechanization in developing countries from a fresh point of view. Obviously, the former meaning is less credible than the latter because there are stronger evidences to show that a fresh approach to the problems is a concept whose time has come.

The fresh approach concept is borne of the need NOW, more than ever before, to reclassify economic development levels attained by many countries resulting from the United Nations' declaration of Development Decade a few years back. Perhaps three, four or more realistic scales can now be drawn among the developing countries corollary to which the improvement and introduction of farm mechanization in those countries should be geared.

Central to this fresh approach concept is the urgent need for international bodies, research institutions and economic analysts like Gunnar Myrdal to undertake the reclassification effort to group the countries of the world today into some realistic levels of economic development attainment. In fact, if such work has already been done, the AMA stands ready to give it the widest publicity.

When such a new scale of economic development is done and known, it will be the turn of the advocates of agricultural mechanization to reexamine their piece; it will be the opportunity of engineers and designers to work out new innovations and technology compatible with the development scale in a given country; and then, it might well be the advent of a new revolution in farm mechanization.

Chief Editor

October, 1979 Yoshisuke Kishida

Tokyo

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. X, No. 4 Autumn, 1979

Some Principles of Mechanization Development for Small-Scale Family Farming

by
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Summary

Some principles for the effective diffusion of farm machinery and mechanization in developing countries that have small-scale farming systems of rice cultivation similar to Japan are discussed on the basis of the national historical experience of family farms.

Concerning some effects of mechanization, the general principles for paddy fields and farming structures and yields are discussed. A concept of land productivity and the relation between income level of family farms and machine prices are reported. A practical guide to be used by agricultural engineers in assessing the potential for tractors and power tillers is explained with a case study. The actual process of farmers' investment in machinery is discussed, and the income structure of small family farms is explained.

* This paper was presented in section III of the 9th International Congress of CIGR, Michigan State University, July 11, 1979, paper No. III-2-19.
The author expresses his appreciation to Dr. Merle L. Esmay, Michigan State University, Dr. Katsuhiko Ikeda and Dr. Tetsuro Taniyama, Crop Scientists, Dr. Taichi Yamamoto, Farm Management Specialist, Mie University, Prof. Charles J. Moss, IRRI, for useful discussion and advice.

Introduction

The average size of a family farm in many Asian developing countries is in the range of from 1 to 3 hectares, 80.4 percent of the total farms are less than 5 hectares and 96 percent are less than 10 hectares in six selected rice growing countries.[1] The average size of Japanese farm is 1.1 hectares, and all the basic work from primary tillage to grain polishing have been mechanized since 1970 in Japan for both transplanting and direct sowing.[2] Direct sowing is applied to only one percent of the total planted area in the country,[3] for it needs unexpected expenditure and labour, yet the yield in general is low. The history of the development and diffusion of farm mechanization in Japan from the 1950s is that of the human experience of mechanizing small, rice growing, family farms.

Many developing nations started to develop their own farm machinery and farmers also started to accept them as well as imported ones from advanced countries. In the promotion rational mechanization, they will meet may problems and some of them will be similar to those that Japan experienced. Selecting useful data from experience, the author intends to discuss and propose some appropriate ideas and principles for mechanizing paddy rice family farms and tractorization in the developing countries.

Effects of Mechanization in Developing Countries

Here are some well known reasons why farm mechanization is effective in increasing food production:[4)5)]

a) Greater speed of operation offers more timely planting, harvesting, etc. and often leads to higher crop yields of better quality.
b) Deeper and more thorough cultivation increases crop yields.
c) Cultivation of barren land by farm machinery increases total farming area and production.
d) Reduction in harvest losses through more timely harvesting, and in processing losses by efficient machinery.
e) Offers option in applying double or multiple cropping systems.

These operations have to be adopted to special conditions in the developing countries and/or tropical farming based on rice cultivation, which is different from upland dry farming in developed countries.

Surplus labour in rural areas of developing countries is a phenomenon during off-season in farm work. It is not correct that there is no surplus labour in the peak season of farm work, especially in ploughing, planting and harvesting.[6] Even on small farms, family labour is inadequate to within a limited time to complete all farm operations such that group working system by hired labour in the season have developed. When the cost of machine operation per hectare becomes a little higher or about equivalent to the cost of labour per hectare, farm machinery will be accepted and the benefit of timeliness for better crop growth and yield will be recognized by farmers. These beneficial effects are more obvious in years of abnormal weather.

It is common knowledge that plants with healthy root systems make for high yields. For paddy rice cultivation, in particular, a sudden change from a traditional shallow depth in ploughing by the use of animals, (8 to 10 cm deep) is likely to bring about better plant growth, hence better yields as a much deeper cut in the soil is realized with the use of powerful machines which allows for better root development. However, the following problems must be realized beforehand:

i) Increased water needs – Increasing the volume of top tilth layer of the soil needs more tillage energy and, consequently, a larger volume of primary irrigation water for saturation and planting will be required.

ii) Endangering the hard pan – The basis of paddy field soil structure is that the hard pan under the top soil is preserved over several decades, in order to avoid excess water losses and to keep rational percolation,[7] and also to have an important function in supporting working men, animals and machines. Once the hard pan is destroyed by too deep cultivation, paddy fields will usually begin to lose irrigation water with the nutrients in it,[10] through seepage because with the breakage of the hard pan the former low-ground water level will become swampy and will result in a high-ground water level. True enough, thick clay soils vary in their water-holding capacities, but the depth of top soil will gradually grow deeper year after year as the destruction of the hard pan is hastened. It has been shown experimentally that about four years are needed to form a new hard pan under a suitable depth of tilth, with careful ploughing in the seasons.[12]

iii) Lower work efficiency – It is not easy to recommend an optimum depth of top soil for this varies according to cultivation technologies and natural conditions. The common depth of tilth for paddy rice in Asia is not traditionally deep because a deep muddy tilth in paddy fields reduces the working efficiency of men, animals and machines. In Japan, for instance, the general depth of the top soil for paddy cultivation was 15 to 18 cm in the 1950s to the 1960s but has been reduced to 12 to 15 cm at the present time essentially because of a low work efficiency in deep top soil.

iv) Lower effective content of manure – Although deepening of the top soil is sometimes expected to release micronutrient in the hard pan to the top soil,[10] sudden deepening generally lowers the effective content of manure. It is advisable therefore, to cultivate gradually more deeply year by year, without destroying the hard pan, and adding a suitable amount of manure. (Only 1 cm deeper ploughing per year was advised from the 1950s to the 1960s in Japan when mechanization started).

v) When a second crop of vegetable or upland crop is planted on the same field in the dry season, Japanese farmers usually prepare ridged soil beds in order to get a deep tilth.

The easy-shattering characteristic of paddy grains at harvest is one cause of grain losses for tropical rice varieties.[4] Harvesting machines in developed countries, in general, have a resonable performance with difficult shattering varieties but not with the easy shattering ones. Solutions to the harvest loss problem should be found from two approaches: one is to develop harvesters, threshers and systems suitable for tropical rice and the other is to develop new varieties of difficult shattering characteristic through breeding. The grain losses in drying, hulling and polishing will be minimized with better application of modern technologies and machinery. However, grain processing after threshing, except for family-consumption, belongs not to farmers but to rice millers or middlemen (sometimes government agencies) in many developing countries, and this is not so in Japan.[2]

Farmers in developing countries are beginning to harvest paddy in the rainy season, owing to the shorter-term maturity and lower photosensitivity of new high-yield varieties.[4]

This increase the application of double cropping of rice in a year[11] and even continuous cropping is being tried in areas with advanced irrigation and drainage systems. Labour requirements for harvest and the immediate planting of the second crop, including tillage within a limited time practically requires full-time employment to traditional labour. As a result, labour shortage in these areas is becoming a serious problem, hence farming is beginning to be mechanized.

Experience in Land Productivity in Japan

A national effort to increase total rice production in Japan has been the obsession until the last two or three years. This was espe-

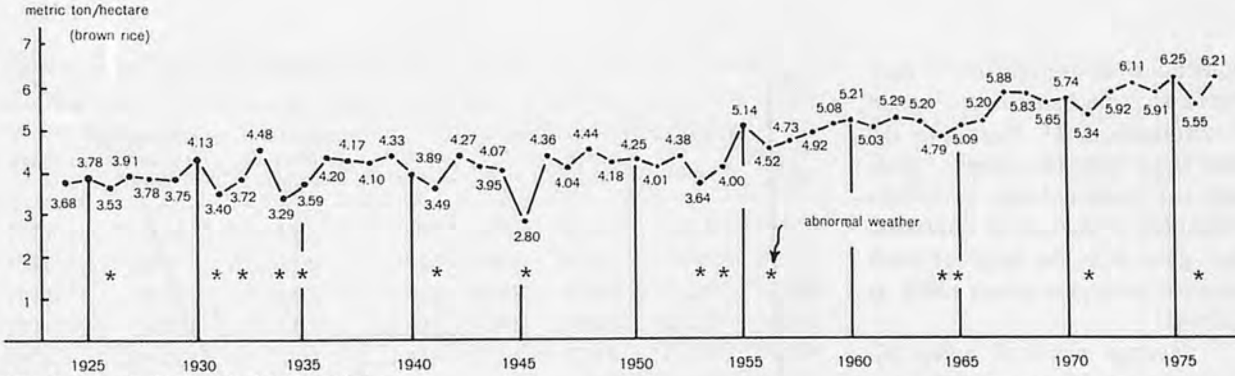


Fig. 1 Historical Trend in Rice Yield, Japan

data by the Japan Ministry of Agriculture and Forestry[3]

cially true since the turn of the century. Shortly, after World War II the nation's 80 million people was on the verge of starvation with arable land of only 6 millions [3]. There was a national food crisis that caused about 45 percent of total population to work in the farm areas.[3] Better technologies for increased production were eagerly accepted by farmers. In the 1950s and 1960s other industrial fields were reconstructed, and grain processing equipment was widely diffused.[2] Real farm mechanization (tractorization)[4] started from about 1960.[2]

Fig. 1 shows that paddy yield[3][8] after 1955 was more stable than before 1950. The low yields before 1950 occurred in years of abnormal weather. Since then, however, timely work with farm machines, new technologies of breeding, fertilizer and irrigation facilities have contributed to stabilizing and increasing the yield. However, it is not easy to ascribe the remarkable increase in land productivity to the popularization of agricultural mechanization after 1960. For instance, double cropping of rice was tried earlier in Shikoku, largely because of favorable weather conditions. The introduction of farm machinery added impetus to the increase in total production on those double-cropped farms. Thus, Japan's experience suggests that the increased paddy yield or increased land productivity was achieved not only through the introduction of farm mechanization except in areas of twice-a-year paddy production.

Land productivity, in fact, is influenced by a mix of many technologies which renders it difficult to isolate one form of technology and ascribe to it a specific fraction of total land productivity. It might be more logical to say that land productivity is raised by compound-interest effects of a number of technologies, which individually produce small increases in yield annually.

Farm Income and Farm Machinery

There are two types of mechanized farming in Japan. One is cooperative farming estate or contractor type where farm machines are not owned privately by farmers. The other type is individual farming where farmers have their own machines. The latter is more popular than the former. Fig. 2 shows the total number of selected farm machines in Japan.[2][3] Fig. 3 shows the historical trend in gross and net incomes of Japanese farm

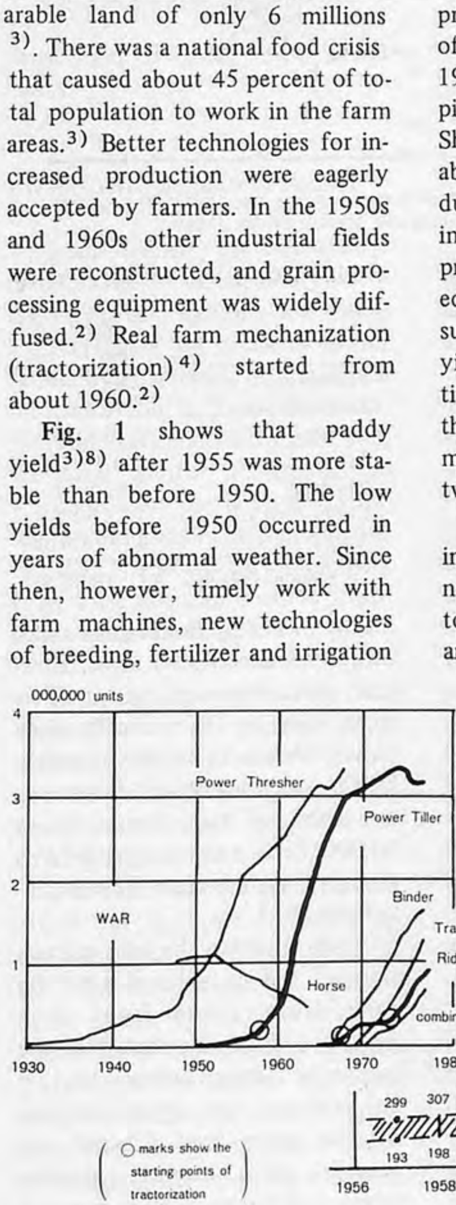


Fig. 2 Diffusion of Farm Machineries, Japan

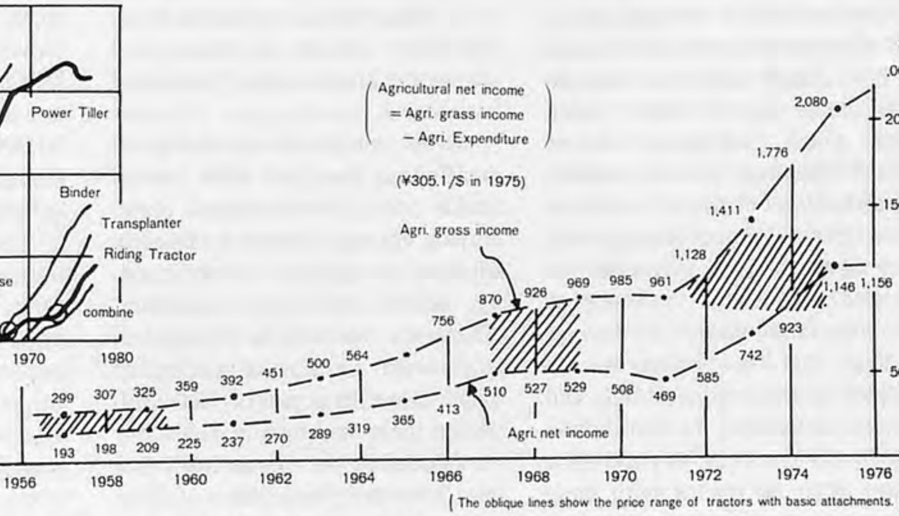


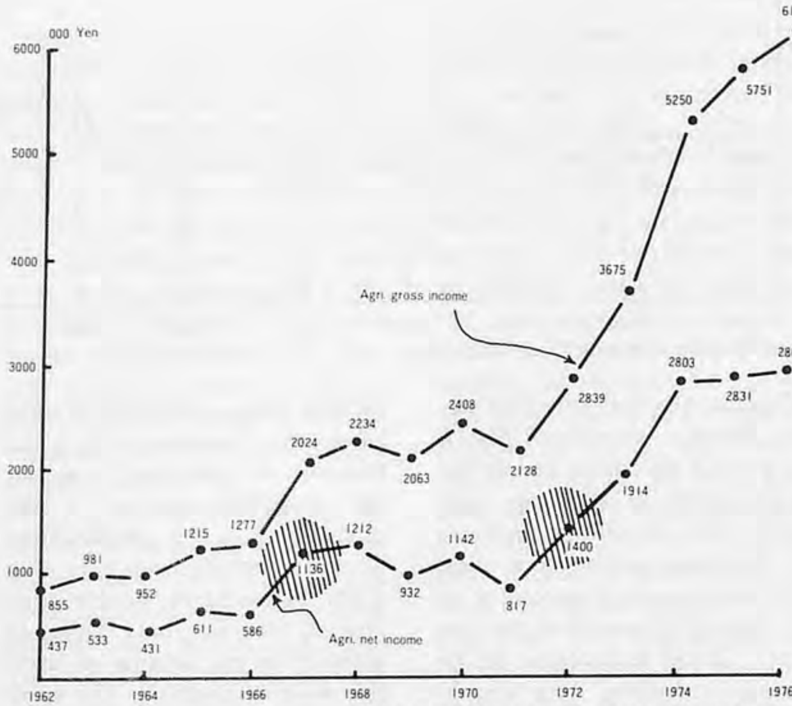
Fig. 3 Trends in Farm Income Growth, Japan

households of average size.[3] Agricultural mechanization means "tractorization".[4] These two figures show that the range of gross and net income levels of a farm household at the start of tractorization grew with the range of retail prices of tractors or power tillers, as follows:

Average prices of power tillers in 1955 and 1957 were ¥178,000 and ¥205,000 respectively without engine,[3] and about ¥230,000 and ¥260,000 with engine. Small riding tractors of 11 to 15 h.p. which came into use from around 1968 were ¥350,000 to ¥945,000. The best selling tractors of 10 to 20 h.p. in 1974 to 1975 were ¥700,000 to ¥1,150,00[3] that include a rotary tiller. **Fig. 4** shows income trends in Hokkaido.[3] Mean prices of the most widely used tractors, 15 to 20 h.p., were ¥727,000 in 1965 and ¥803,000 in 1967.[3] The most common tractors in Hokkaido in 1972 and 1973 were 20 to 30 h.p. which cost about ¥900,000 to 1,400,000 without tillers.

It is better that the purchasing power of a farm household be discussed with data on both economic surplus and annual expenditure for farm machinery. Economic surplus of a farm household has to be calculated from its agricultural and non-agricultural income minus all the farming and living expenditures, taxes and so forth, which need much statistical information.[8] However, it is not realistic for agricultural engineers to discuss these items of the developing countries in which there are usually no detailed statistical information about the family farm economy.

Thus, the observation on the basis of general statistical data and farmers' behaviour; "a farm household has a tendency to purchase a power tiller or tractor with basic attachments, when the agricultural gross or net income becomes higher than or about the same as the retail price of the machinery.". This is a practical assumption for engineers when they design and develop efficient farm machines and do extension service for developing countries. They should develop a power tiller or tractor with basic attachments, at a retail price the same or lower than the agricultural gross income level of family farms. Such machinery has the possibility of being purchased by them individually. Otherwise a co-operative or contractor system of buying and owing the tractor might be a good alternative.



(The oblique lines show the price range of tractors without attachments)

Fig. 4 Relationship Between Farm Incomes and Tractor Prices, Japan

Gross income is obtained by multiplying the total yield by the paddy price from the farmer to the buying agency. The price of paddy changes according to variety, quality, season and social conditions These are not usually reported in government statistics or in scientific papers, but Palacpac of IRRI collected them as shown in **Table 1**.[9]

Table 1. Comparative Paddy Price

Country	Paddy Price /kg, 1974
Philippines	0.89 ₱
Sri Lanka	1.51 Rs.
Burma	0.29 Kyat
Japan	181.54 Yen
Thailand	2.43 Baht
China, Rep. of	10.2 NT $
Korea	132.74 Won

Source: Palacpac, A.C., IRRI. 9)

According to the author's survey, imported power tillers of 10 to 14 h.p. in the Philippines were mainly owned by farm families who owned 15 hectares or more. However, annual sales of power tillers were only a few. Locally-made power tillers were purchased mainly by farmers who owned 5 hectares or more of rice farms. About 10,000 units were bought by this group of farmers annually especially from 1975.

Table 2 shows the trial calculation of the agricultural gross income level of rice farms. It is presumed from this table that the income of farms of average size (3.6 ha) has not yet approached the machine price level although the income of 5-hectare, double-cropped or better-yielding farms of average size was moving beyond the

Table 2 Gross Income in Philippine Family Rice Farms

Year	Producer Price of Paddy 1) ₱/cavan	Average yield 2) cavan/ha	Gross Income of Single Crop (₱)					Price of 10 ps Power Tiller with Rotary Tiller (imported)	Price of 6 ps Power Tiller with Plough, Rotor, Wheel (local made)
			1 ha	3.6 ha	5 ha	10ha	15 ha		
1970	15.84	38.2	605	2,178	3,025	6,051	9,076	10,000₱	₱
1971	24.2	39.1	946	3,406	4,731	9,462	14,193		
1972	26.84	35.7	958	3,449	4,790	9,582	14,373	17,000	
1973	34.76	32.3	1,123	4,042	5,614	11,227	16,841	3)	3)
1974	39.16	37.0	1,449	5,216	7,245	14,489	21,734		
1975	40.92	36.4	1,489	5,362	7,447	14,895	22,342	23,000	
1976	49.28	40.5	1,996	7,185	9,979	19,958	29,938	29,000	8,000
1977	–	–	–	–	–	–	–	34,000	

1) Palacpac, IRRI,[9] ₱/kg x 44, (₱7.51/$ in 1975)
2) Department of Agriculture, Philippines
3) Sakai, Nueva Ecija, Central Luzon

price level of locally-made power tillers.

Investment Decision Process

Small farmers do not always decide to invest in machinery solely on the needs of farming operations. **Fig. 5** shows the gains in labour productivity achieved by small scale mechanization in Japan.[3] Mechanization has reduced to half both the total number of farmers and working hours per hectare. By observing the gains in land productivity (**Fig. 1**) and labour productivity (**Fig. 5**), a farmer's decision ought to be made as follows:

1st step: Consider the probability of saving wages on the farm, and deduct the cost of operation of the machine. This probability is low because of the low wages paid on farms and the small scale farms in developing countries.

2nd step: Consider the economic return on the part of his gross income obtained by an increase in the planted area of his main or other crops minus the cost of operation of the machine when he has uncultivated land or the possibility of double or multiple cropping. When irrigation and drainage is available, the cropping intensity can often be increased.

3rd step: Consider the increase in total income of his whole family from other jobs. If his farm is already well utilized and there is no possibility of increasing the cultivated area, he should consider:

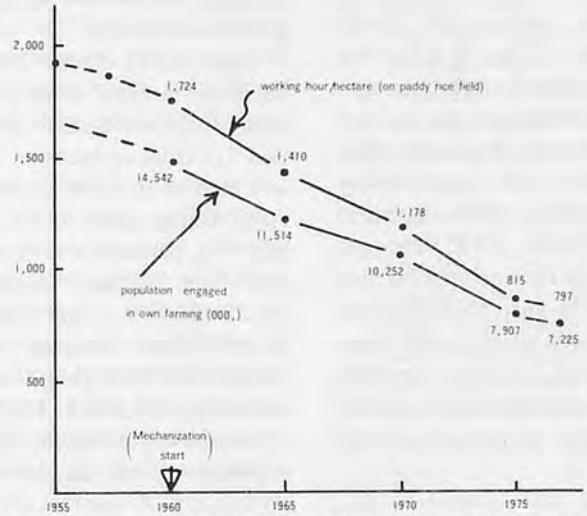


Fig. 5 Trend in Work Hours/Hectare and Population Engaged in Farming, Japan

(a) custom operation with his machines. (According to the author's investigation in Central Luzon in the Philippines, a 6-h.p. power tiller of local make with basic attachments cost about ₱8,000 in 1976, while the custom operation of primary tillage with puddling cost P200 to 250 per hectare. Farm machines are usually purchased from loans. Then if the machinery was purchased on a four-year repayment plan of the CB-IBRD loan, the annual repayment would be about ₱2,000 plus 14-percent bank interest, for which the custom operation on about 10- to 15-hectare land was needed in a year, besides machine-running expenditure.)

(b) offering labour surplus from his family to another productive job in non-agricultural sectors. (This means that the family farm will begin to look for a "side" business or another stable economic activity. If other industries in a country show a tendency toward development, they will grow as they absorb manpower from the agricultural sector. In Japan, farmers hesitated to sell their fields for the sake of the family's security, and part-time farming households increased with the development of farm mechanization and other industries.)

When farmers consider these steps and find they are able to repay loans, they will buy the machinery for their farms. It is usual for them to find multiple solutions from these steps and to have gainful economic activities as the following section will show.

Structure of Family Farm Incomes

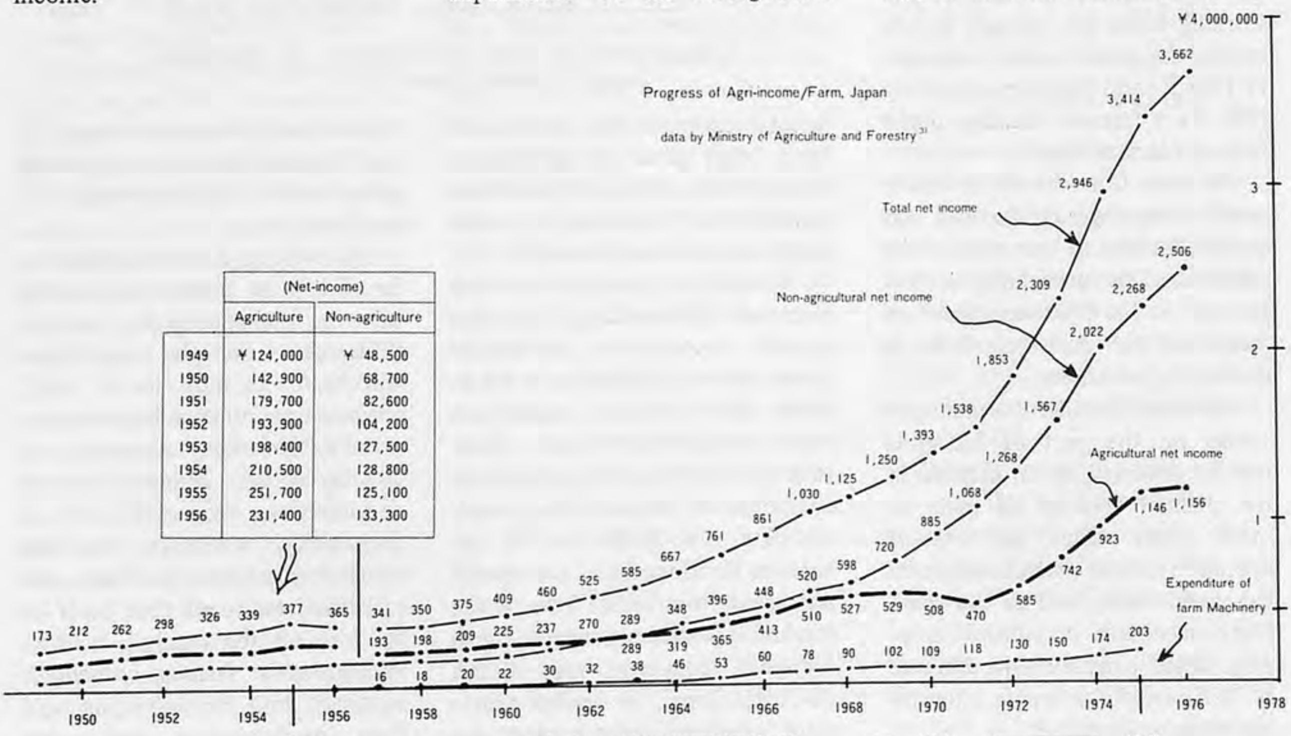
The income of a farm family may come from agricultural and non-agricultural activities. Fig. 6 shows the historical trends of these incomes for average-size family farms in Japan.[3] About 2/3 of the total income was derived from agriculture and the balance was derived from non-agricultural pursuits when animal power was used before 1955. When power tillers came into the market after 1955 the gap between those two incomes became smaller year by year, particularly in the early 1960s when power tillers started to sell in great numbers which was accompanied by higher rate of growth of non-agricultural income.

When in 1968 power tillers saturated the farms in Japan, practical transplanters and harvesters (reapers and binders) were successfully developed (**Fig. 2**). These machines brought about rapid progress in labour productivity for harvesting and planting, so that the unstable labour surplus became a stable labour source throughout the year. This enabled farmers to work or transfer into other industries to increase the non-agricultural income of their families. This tendency was also accelerated when combine harvesters started to be popular in farming.

Since 1971 about 2/3 of the Japanese farmers' total income has come from non-agricultural sources and 1/3 from agriculture. The total net income in 1976 of an average-sized family farm of 1.1 hectares and 4.6 persons was ¥3,662,000 and the gross income was ¥5,388,000 (net income x 3/2)[8], about $20,000. It is presumed that their gross income was more than $30,000 in 1978.

As shown in **Fig. 6**, the annual expenditure of an average-sized family farm on farm implements for purchase and maintenance during 1955 to 1960, at the end of animal era, was less than 10 percent of the agricultural net income. In 1961 when rapid diffusion of tractors started, this investment became more than 10 percent for the first time and approached a little less than 20 percent in 1969 and has since maintained this percentage, increasing the actual amount with growth of income.

As stated earlier, farm mechanization in Japan did not record remarkable increases in land productivity. This means that expenditures on farm machinery is hardly repaid from increase in the yield of the main crop on the small farms. If non-agricultural income of family farms had remained about a half or less of agricultural income, their expenditure on farm machinery might not have grown to more than 10 percent of agricultural net income. If so, the speed of mechanization would have slowed down to less than half of the previous national record. That will probably happen in those countries which



	(Net-income)	
	Agriculture	Non-agriculture
1949	¥124,000	¥ 48,500
1950	142,900	68,700
1951	179,700	82,600
1952	193,900	104,200
1953	198,400	127,500
1954	210,500	128,800
1955	251,700	125,100
1956	231,400	133,300

Fig. 6 Progress of Agri-income/Farm, Japan

have insufficient development of non-agricultural industries.

In Japan, farmers' investment in machinery is made in the hope of increasing the total family income mainly by non-agricultural work. These are also some trials and expectation of agricultural income from intensive agriculture, double or multiple cropping and/or livestock farming. Some developing countries may have potential for such intensive agriculture. In addition to this, non-agricultural income of small-scale family farms will also become one of the important factors in promoting agricultural mechanication.

Conclusion

The depth of ploughing paddy rice fields in developing countries has to be reconsidered for the establishment of effective farming. The plough pan made by traditional animal ploughs must not be destroyed by abruptly changing to deep tillage with farm machinery. Sudden destruction of the plough pan makes top soil too deep, muddy and swampy and results in inefficient irrigation and drainage and low working efficiency of men and machinery. It has to be deepened gradually year by year.

The main purpose of farm mechanization is to increase land and labour productivity. However, land productivity does not easily increase as labour productivity. As a rule, land productivity progresses gradually at compounded interest by a mix of technologies that produce small increases individually. Increased land productivity through double, multiple or continuous cropping which is possible in mechanized farming with adequate irrigation and drainage, especially in tropical zones, is one method of expanding the land area.

The purchase of farm machinery has a close relationship with farmers' income. Tractorization in Japan showed a tendency to start and be accelerated when the agricultural net and gross incomes of average-sized farms exceeded the retail price of power tillers or tractors with basic attachments. This phenomenon can be used as a practical guide for agricultural engineers to have R&D activities and extension service for farm machinery in developing countries where information on family farm economy is insufficient.

The small farmers' decision process in purchasing machinery is made by considering the probable economic returns from additional, non-farm economic activities.

The mechanization of small-scale farms in Japan was achieved rapidly within two decades due in part to a fast development of new machinery suitable to local conditions and in part, to the increase in total income of family farms derived from economic activities in other industries. Thus, agricultural mechanization and other industries are complementary. The non-agricultural income of small-scale family farms will become one of the important factors in promoting agricultural mechanization in developing countries.

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Comparative Farm Returns: A Case of the Project and Non-project Farms in the Chao Phya Basin of Thailand

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Introduction

In recent years, relative rates of return to resources in agriculture have become increasingly important and received considerable attention. A number of studies have been made by estimating the rates of return to resources of particular farm group and then comparing these with the estimated rates of return to similar resources of other farm group. The comparative efficiency can then be determined. The results obtained by this way of analysis would be more meaningful and truly reflect the real situation if the two farm groups were operating within a similar agricultural environment. Such a condition is not possible. It is more interesting to study the relative rates of return to resource use under alternative circumstances. Land consolidation programme represents the alternative form to be analyzed in the present study. As many authorities concerned always contend and come to an agreement that an improvement in economic and technological settings in the form of land consolidation would result in an efficient use of resources as well as an incentive to induce more investment in crop production, comparisons of rates of return to various resources used in well-developed land consolidation and less-developed areas would provide an answer to the question.

The primary objective of this study is to analyze the relative rates of return to resource use and the distribution of farm income under different production circumstances. The specific objectives are: 1) to determine the magnitude of individual input share in the total farm returns and to estimate the relative rates of return and net returns per unit of input, and 2) to examine the variations of returns ratios and farm returns between and within farm groups and to analyze the distribution of farm income and the rates of profit among different land holding sizes. All estimations in this paper are related to non-project farm returns as a standard of comparison.

Data Source and Estimation Procedure

Data Source

The farms selected for this study are those located in four areas, i.e., two areas (project) with land consolidation programme located in the Chanasutr and Boromdhart districts and other two areas (non-project) located adjacent to those two districts (see **Fig. 1** for the two areas and **Figs.** 2 and 3 for the before and after implementation of the project). A randam sample of 288 rice farmers (rice is the main crop accounting for almost 100 percent in the wet season and about 95 percent in the dry season) was selected from different irrigation zones in the four areas. The sample was also taken so that it was representative of three farm sizes: small farms, 0–20 rais; medium farms, 21–40 rais; and large farms, above 40 rais (1 rai=0.16 ha) of the total sample, 152 farms are in the project area and 136 farms in the adjacent areas. **Table 1** provides some information on characteristics and income levels of the sample farms.

Estimation Procedure

In this study farm returns are defined as the difference between the value of production and the production costs. Generally, farm returns are not limited to gross farm sales minus production costs and depreciation but include other items such as income in kind and capital gains. Since the study concentrates on the impact brought about by the project, income which it directly generates is of significance for comparison. Hence, income in kind as part of farm

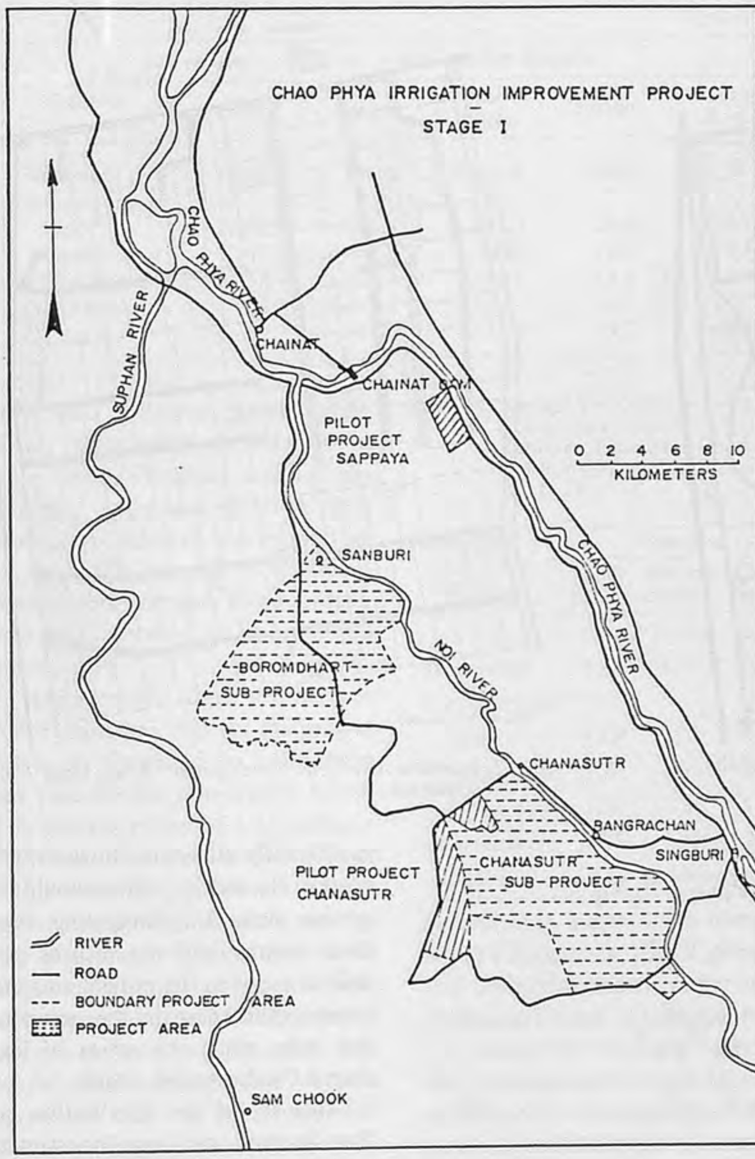

Fig. 1

returns is excluded. Capital gains to farm assets were also excluded because of the lack of reliable data and the nature of farm business wherein most farms have not accumulated savings through investment in farm assets.

Production costs consisted of two main components: variable and fixed costs. Variable costs apply specifically to all purchases of fertilizers, plant protection chemicals, seeds and fuel for machinery, payments of hired machine and wages for hired labor. Fixed costs included depreciation of equipments and buildings, repair, rent for land and interest on borrowed capital.

Estimating unpaid land cost and family labor is a problem that to some extent has hampered the accuracy of estimated costs. To solve the problem, a proxy for the value of the input was used. The rental value of owned land was estimated by using local average rent charged in the four areas. For the unpaid family labor, family and hired labor were assumed as homogeneous and their productivities are the same. The imputed cost was, therefore, estimated by the wage rate paid for hired labor.

Equipments and buildings presented another major problem. Theoretically, the costs of these durable inputs are their capital ser-

Table 1 Summary of Farm Business Data, by Farm Sizes, Chanasutr and Boromdhart Districts, 1977–78

(per farm)

Farm Size	Number of Farms	Land Area (rai)	Labor (man-day)	Fertilizer Investment (Baht)	Capital Cost (Baht)	Average Gross Income (Baht)	Average Net Income (Baht)
Project Area:							
Small farms	88 (58 %)	13.0	138.7	1,077.7	3,470.6	15,122.8	4,187.1
Medium farms	47 (31 %)	30.6	260.8	1,518.8	6,323.3	37,116.4	13,015.4
Large farms	17 (11 %)	50.7	520.7	3,269.8	12,314.5	62,242.3	22,507.6
All farms	152 (100 %)	24.7	235.7	1,527.4	5,726.6	27,192.9	8,965.8
Non-project Area:							
Small farms	85 (62 %)	16.3	125.5	1,089.6	4,006.1	14,442.5	3,177.3
Medium farms	38 (28 %)	31.3	210.4	1,202.8	8,171.7	34,568.1	12,145.4
Large farms	13 (10 %)	55.8	445.7	1,038.3	10,295.7	57,667.8	27,571.9
All farms	136 (100 %)	29.9	221.7	1,129.3	6,838.4	24,197.2	8,014.9

Note: 1 rai = 0.16 ha., 1 baht = 0.05 US$

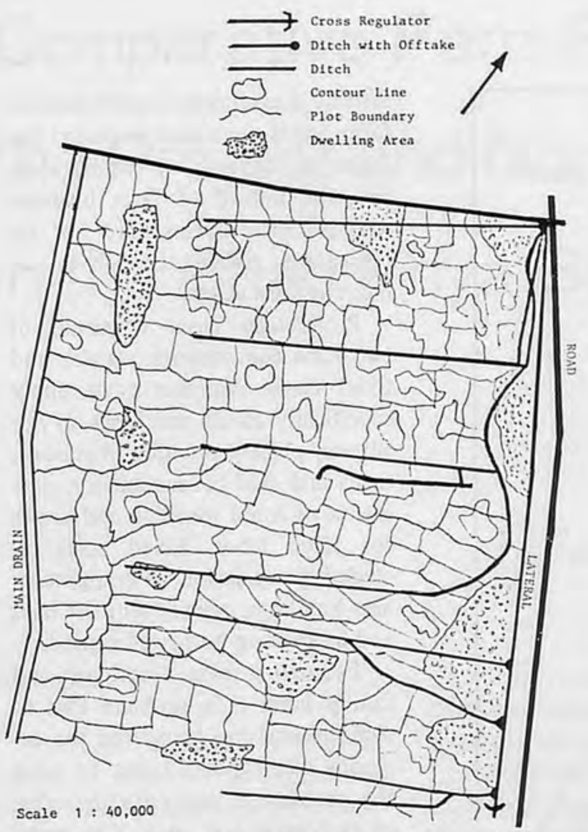

Fig. 2 Irrigation Facilities Before Implementation of the Project

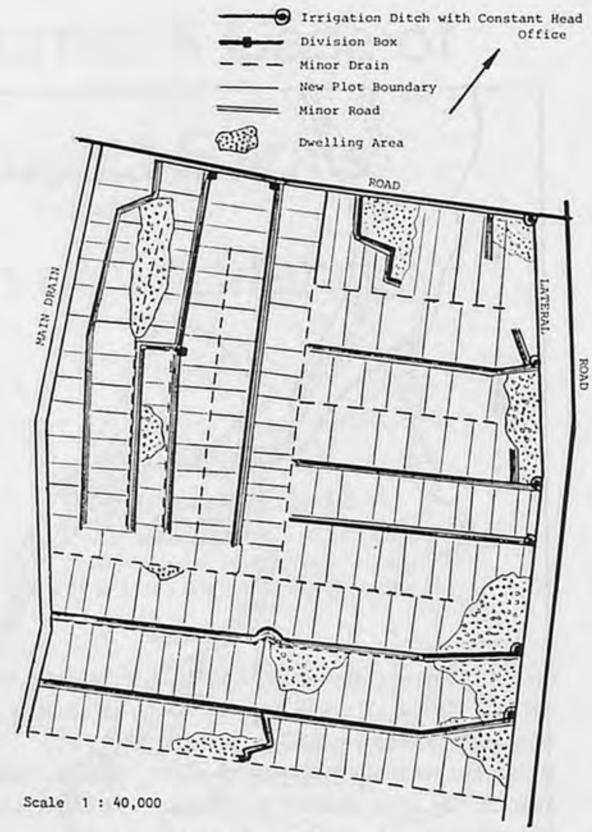

Fig. 3 Incentive On-Farm Development After Land Consolidation

vice flows. But measures of services are difficult to construct and are seldom available in published statistics (5; p. 27). The problem was solved by segregating the items of durable inputs and asking farmers to quote the original purchase price and evaluate the expected usable life of each input. Then the straight-line method to derive the annual capital service flows was applied.

The basic formulae used for estimations are given in the following equations. Suppose a production function for a farm of i group(s):

$$Q_i = f(X_{ij}) \quad \ldots\ldots\ldots\ldots (1)$$

where

Q = amount of output per farm;
X = amount of inputs used per farm;
i = 1, 2 (project = 1 and non-project = 2);
j = 1,2,3, 4 and 5 denote land, family labor, hired labor, fertilizer and capital, respectively;

and

$$\bar{Y}_i = \bar{P}_i.\bar{Q}_i - \bar{P}_{ij}\bar{X}_{ij} \quad \ldots\ldots\ldots (2)$$

$$\bar{R}_{x_{ij}} = \bar{Y}_i.\bar{X}_{ij}/\bar{C}_i \quad \ldots\ldots\ldots (3)$$

$$R_{x_{ij}} = \underset{i=1}{\bar{R}_{x_{ij}}} / \underset{i=2}{\bar{R}_{x_{ij}}} \quad \ldots\ldots\ldots (4)$$

$$r_{x_{ij}} = \bar{R}_{x_{ij}}/\bar{Q}_{x_{ij}} \quad \ldots\ldots\ldots (5)$$

$$R_{r_{x_{ij}}} = \underset{i=1}{r_{x_{ij}}} / \underset{i=2}{r_{x_{ij}}} \quad \ldots\ldots\ldots (6)$$

where

$\bar{R}_x$ = share of input X in farm returns;
$\bar{Y}$ = average net income;
$\bar{X}$ = average cost of input X;
$\bar{C}$ = average total cost;
R_x = relative rates of return of X;
r_x = net returns per unit of input X;
$\bar{Q}_x$ = average quantity of input X;
R_{r_x} = relative rates of net returns per unit of X;
$\bar{P}$ = average price of output;
$\bar{p}$ = average price of input X.

Since the supporting infrastructures of the two areas are quite significantly different, all we expect a priori R_x and R_{r_x} ratios would be greater than 1.0, indicating that farm returns and net returns per unit of input in the project area are greater than those in the non-project area, while the ratios of less than 1.0 indicate the reverse.

Analysis of the distribution of farm income was done by estimating the relative share of each farm size in the total farm returns.

Results of the Estimation

Results of the estimation are shown in **Tables 2, 3, 4, 5, 6, 7** and **8** and discussed below.

Input Shares and Relative Rates of Return

As indicated in **Table 2** input shares in the total farm returns in both areas were more or less the same. Capital had the largest share, followed by hired labor, land and family labor. For the non-project

Table 2 Average Yearly Project and Non-project Farm New Returns and Returns Ratios, Chanasutr and Boromdhart Districts, 1977–78

(Baht)

Farm and Factor Returns	Wet and Dry Seasons				
	Project	Percent	Non-project	Percent	Returns Ratio
Total return	8,965.8	100.0	8,014.9	100.0	1.12
Factor return;					
Land	1,642.5	18.3	1,684.5	21.0	0.97
Family labor	1,347.8	15.1	1,455.6	18.2	0.93
Hired labor	2,058.4	22.9	1,209.6	15.1	1.70
Fertilizer	824.8	9.2	519.5	6.5	1.59
Capital	3,092.3	34.5	3,145.7	39.2	0.98

Table 3 Average Yearly Project and Non-project Factor Net Returns per Unit and Returns Ratios, Chanasutr and Boromdhart Districts, 1977–78

(Baht)

Factor Return	Wet and Dry Seasons		
	Project	Non project	Returns Ratio
Land	65.6	56.8	1.16
Family labor	14.4	12.5	1.15
Hired labor	13.9	10.6	1.32
Fertilizer	1.6	1.7	0.95
Capital	53.6(%)	46.4 (%)	1.16

area, land followed capital, while family labor share exceeded hired labor share. Fertilizer was not significant, reflecting from its low level of application. It is interesting to note that inspite of abundant family labor, farmers in the project area still resorted to more hired labor.

Average total farm returns was 8,965 Baht per year for the project famrs as compared to 8,015 Baht per year for the non-project farms. The returns ratios of 1.12 indicate that resources used by the project farms earned 112 percent of the returns to similar resources used by the non-project farms. But when individual inputs are considered, only hired labor and fertilizer input returns ratios were greater than 1,0, while other inputs had returns ratios less than 1.0. Even supported by better facilities, land in the project area did not earn much as compared to land in the outside area. However, these figures do not really tell much unless the amount of individual inputs are taken into account.

Net Returns Per Unit of Input

Figures on the net returns per unit of input and their returns ratios are given in **Table 3**. The net returns of land in the project area, for example, was 65.6 Baht per rai as compared to 56.8 Baht per rai in the outside area. Except for fertilizer, the net returns of other inputs used in the project area were greater than those of inputs used in the outside area, suggesting a favorable relative efficiency. On a comparative basis, the returns ratios in this case were found to be greater than 1.0, except for fertilizer, indicating that, for example, if hired labor was employed to work in the outside farms it could expect to earn only 76 percent of what it could have earned in the project farms.

Table 4 Average Yearly Project and Non-project Farm Returns Ratios by Farm Size, Chanasutr and Boromdhart Districts, 1977–78

Farm and Factor Returns	Farm Size		
	Small Farms	Medium Farms	Large Farms
		ratios	
Total return	1.32	1.07	0.82
Factor return:			
Land	1.11	1.08	0.59
Family labor	1.20	0.93	0.56
Hired labor	1.94	1.86	1.17
Fertilizer	1.37	1.40	2.04
Capital	1.23	0.86	0.78

Variations of Returns Ratios and Farm Returns

Table 4 shows the returns ratios of total returns and factor returns of different farm groups classified according to farm size. It appears that the returns ratios of total returns decreased significantly with increases in farm size, reflecting the fact that in the project area small farms were more profitable than large farms when compared with their corresponding sizes in the outside area. For the medium-sized farms the returns ratios of close to 1.0 indicates that the total returns of the two areas were insignificantly different.

Table 5 Average Yearly Project and Non-project Factor Returns Ratios byFarm Size, Chanasutr and Boromdhart Districts, 1977–78

Factor Returns Per Unit	Farm Size		
	Small Farms	Medium Farms	Large Farms
		ratios	
Land	1.37	1.11	0.65
Family labor	1.37	1.10	0.65
Hired labor	1.98	0.98	0.92
Fertilizer	0.86	1.09	0.85
Capital	1.37	1.11	0.65

As for the returns ratios of inputs it may be observed that only the returns ratios of hired labor and fertilizer showed less variations, while those of other inputs followed the same pattern as the returns ratios of total returns.

The variations of the returns ratios of net returns per unit of input (**Table 5**) between farm groups were strongly pronounced for all inputs, except fartilizer. The differences showed the relative advantages and disadvantages of resource use in the small and large farms in the project area.

For comparative purposes, however, an additional measure of variability of farm returns is required. Such a measure is obtained by expressing the standard deviation of farm returns as a percentage of the average farm returns of each farm group. The resulting figures, refer-

Table 6 Variability of Farm Returns by Size, Project and Non-project areas, 1977–78

(Percent)

Farm Size	Coefficient of Variation	
	Project	Non-project
Small farms	144.6	226.3
Medium farms	85.4	89.9
Large farms	67.6	63.1
All farms	123.4	151.9

red to as the coefficient of variation (2; p. 197), are shown in **Table 6.** The coefficients of variation estimated for the two areas reveal high levels of variability among individual farms. The small farms exhibited the greatest variablities of 144 and 226 percent for the project and non-project farms, respectively. The variablity declined as farm size increased and became smallest for the large farms in both areas. For all sizes the variability was less pronounced but were still relatively less uniform in farm returns.

Distribution of Farm Income

The study was also concerned with the relative distribution of farm income within farm groups. To evaluate the distributional aspects of the project, the average net income or total returns as defined earlier were distributed across different farm groups. **Table 7** shows both the absolute and relative shares of average net incomes. Apparently, from the absolute shares, the average net incomes among groups were considerably different, thus resulting in disproportionate shares in relative terms. The small farms' (58 percent of the total sample farm) share was only 10 percent, while the large farms' (11 percent of the total) share was as large as 57 percent of the total average net income. Average net income difference between groups was also significant as it appears that the average net income of the small farm was about 32 and 17 percent of those of the medium-sized and large-sized farms.

Table 7 Average Net Income by Farm Size; Project and Non-project Farms, 1977–78

Farm Size	Average Net Income		As Percentage of Project
	Project	Non-project	
	Baht		
Absolute Shares			
Small farms	4,187.1	3,177.3	75.9
Medium farms	13,015.4	12,145.4	93.3
Large farms	22,507.6	27,571.9	122.5
All farms	8,965.8	8,014.9	89.4
Relative Shares	Percent		
Small farms	10.5	7.4	
Medium farms	32.8	28.3	
Large farms	56.7	64.3	

Table 8 Rates of Profit, Profit over Wages, and Wave-Cost Ratios by Farm Size, Project and Non-project Farms, 1977–78

(Percent)

Farm Size	Project			Non-project		
	m/(c+v)	m/v	v/(c+v)	m/(c+v)	m/v	v/(c+v)
Small farms	43	112	34	31	94	30
Medium farms	71	185	29	64	214	25
Large farms	61	160	35	94	229	40
All farms	54	141	35	46	134	37

Note: m = profit, c = capital cost, v = wage cost

A comparison of the absolute and relative shares of average net income between the areas reveals that only the operators of small- and medium-sized farmers benefited from he project. But the average net income difference was not so impressive as, for all farms together, it shows the excess average of 950.9 Baht or about 12 percent over the non-project farms.

Rates of Profit

The rates of profit can be measured in terms of costs, capital assets, or wage funds. The ratios of profit to costs, the profit margin, is generally called the rate of profit (3; p. 75). This section tries to determine the rate of profit and analyzes its relation with profit over wages and wage-cost ratio. **Table 8** shows the results of the estimates. In contrast to the non-project estimates, all estimates for the project seem fairly high. In most cases, however, it indicates that small farms were the least profitable.

Conclusions

The findings have shown the relative efficiency and distributional aspect of alternative forms of farming. By comparing the magnitude of total returns, returns ratios, net returns per unit of input, and variations of those ratios of the project farms with those of the non-project farms, the profitability of the land consolidation programme becomes apparent. Though there were some differences in relative rates of return in individual farm groups, the overall rates were satisfactorily high, indicating that to some extent the project did help increase input efficiency and thus farm income.

As for the distributional aspect, in an effort to determine the project desirability, absolute and relative shares of average net income of both areas showed that the pattern of the distribution of income was far from satisfactory. The desirability of the project with regard to the distributional aspect therefore appears less appealing.

(Continued on page 26)

Farm Mechanization in the Rep. of China

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Background Information

The Rep. of China has an area of 35,990 sq km^2 and a population of 16.8 million. The density of population is 467 persons sq km^2.

There are 873,000 farm families (about 5.6 million persons or 33% of the total population) and 923,000 ha of cultivated land. Each farm family consists of six to seven members and holds and average of 1.06 ha of land only.

Farm labor numbers about 1,615,000 persons – 27% of the total labor force (6,030,000). Rural labor decreases year by year due to the attractive work in factories or the fancy life style in cities.

Table 1. Production of Major Crops

Crop	Average (1,000 ha)	Production Total (1,000 tons)	Production Average (tons/ ha)
Rice	778	3,310 (2,649)*	4.25 (3.40)*
Vegeta- bles	202	2,587	–
Sugarcane	119	11,037	92.75
Sweet potato	109	1,695	15.55
Peanut	53	77	1.45
Oranges	34	369	–
Soybean	30	52	1.73
Banana	11	252	24.00
Tobacco	10	25	2.50
Pineapple	9	282	30.00

*Brown rice.
Source: Taiwan Agricultural Yearbook, 1978 edition.

More than half of the cultivated lands are paddy fields, hence rice is the most important crop. Summer crops are vegetables while winter crops include corn, soybean, tobacco, flax, rapeseed, sweet potato, and vegetables.

Table 1 shows the area, production and yield of leading crops.

Farm Mechanization

Farm mechanization has at least one, sometimes all, of the following advantages: i) saves labor; ii) reduces farming cost; iii) increases agricultural production; and iv) improves working conditions. The saving of labor is the main motive of farm mechanization development in the country. Owing to the small land-holdings of individual farmers, the commonly used agricultural machines are of small types.

The development of machines for rice cultivation is the first requirement in the promotion of farm mechanization program. So far, there are many local-made types of power tillers, rice transplanters, sprayers, rice combines, threshers, dryers and nursery equipment available in the market. Some of these machines can also be used for other field crops. The development of machinery for forestry, fisheries and animal husbandry is still in its infancy.

This paper attempts to describe briefly the status of farm mechanization and measures adopted in the Rep. of China.

Power Tiller and Tractors

Farm mechanization in land preparation is already well established in the country. The wide use of power tillers is a good example. They are mostly used in paddy-fields, especially on water-logged soil. Before the end of 1977, a total of 66,698 units of power tillers were used. On the basis of 923,000 ha cultivated land and 873,000 farm households, there was approximately a power tiller among every 13 farm households or every 13.8 ha of land. With the power tillers increasing, the draft cattle have since 1966 decreased in number at the rate of about 20,000 head annually (**Table 2**).

Table 2. Distributiin of Power Tillers and Draft Animals

Year	No. of Power Tillers (Unit)	No. of Draft Animals (Head)
1955	9	412,018
1960	3,708	417,122
1965	12,213	370,370
1970	28,292	275,007
1975	49,347	195,770
1976	55,748	188,748
1977	66,698	122,144

While power tillers remain the backbone of mechanized farming, small tractors of 25-hp or so are also used by local farmers and big wheel tractors of 70 hp have been introduced into the country. In 1971, about 500 ha of paddy-fields were prepared by tractors equipped with rotary tillers under a demonstration program conducted by the Taiwan Sugar Corporation and the Taiwan Seed Service. Since then, a small number of farmers as well as township farmers' associations have begun to adopt this more efficient implement. The number of wheel tractors is shown in Table 3.

Seeder and Transplanter

Rice transplanting is still mostly done manually in the Rep. of China. It is a backbreaking and time-consuming job. According to one study, about 19 per cent of the total labor hours required for rice culture is devoted to transplanting operations.

In order to accelerate the general adoption as well as to show the advantages of using the transplanter, the Government helped the local township farmers' associations and groups of farmers to grow healthy seedings in a cooperative manner. About 350 nursery centers each supplying seedlings to 100 ha of riceland have been organized. About 11,138 units of transplanters have been adopted by rice farmers (Table 3).

Besides hand transplanting, direct seeding for the second rice crop has also been adopted. About 23,000 ha of paddy-fields were directly seeded with some 4,700 seeders in 1977. The seeders are locally manufactured. They are of manual-pulling type and simple in construction. A 6-row seeder costs only NT$1,300 or US$34.

On the other hand, several kinds of planters for dryland crops have been imported and/or locally developed for demonstration purposes. Among them is a local-made peanut planter which is equipped with a belt-type seed metering device and has shown promising results in a preliminary field test.

Table 3. Distribution of Major Agricultural Machinery

(Units)

Machinery	1960	1965	1970	1975	1976	1977
Power tiller	3,078	12,213	28,292	49,347	55,748	66,698
Tractor	487	425	539	1,380	1,718	1,879
Rice transplanter	–	–	280	2,787	6,108	11,138
Power sprayer	317	4,489	17,820	37,874	37,489	45,582
Water pump	8,378	32,107	52,794	124,626	123,645	141,210
Rice thresher	177,338	205,784	186,398	138,474	128,232	133,322
Grain dryer	–	150	198	2,419	9,269	18,147
Rice combine	–	–	20	2,010	2,811	3,930

Water Pump

Water pump was introduced into this island from Japan about 50 years ago. After World War II, the local machine manufacturers turned out about 2,000 units of pumps annually to meet the local requirements. At present, about 140,000 units, including deep well pumps, are owned by farmers for irrigation purposes (Table 3). Now more than a dozen local manufacturers are producing water pumps for local use and export.

Sprayer

In 1977, about 228,000 sprayers, 20,000 hand dusters, and some 45,000 power-driven sprayers and dusters were owned by local farmers (Table 3). Since 1967, aerial pesticide application over paddy fields and banana plantations by mounting sprayers and dusters on helicopters was introduced by the government and farmers' associations.

Harvester

Threshers driven by a small 3-5 hp gasoline engine instead of a pedal have been developed and widely adopted by local farmers in recent years. At present, there are about 133,000 rice threshers still being used in rural areas. The figure is less than that of a few years ago, serving to show that more farmers have adopted the highly efficient power-driven threshers. Improved power threshers equipped with cleaning devices have been developed and extended to local rice farmers, too.

In 1967, two kinds of hand-reapers, pushing and pulling, modified from Japanese-designed ones were manufactured locally for farm extension service purposes. However, they have not been extensively used due to higher grain loss and other drawbacks. So, the production of the reapers were soon abandoned. Both the hand pushing and pulling reapers are no longer in use. In the meantime, some 3,800 power-driven reapers have been introduced from Japan for trial use.

In 1970, a number of small Japanese-made rice combines consisting of a reaper and an ordinary automatic power thresher were introduced by the local manufacturers for testing purposes. So far some 3,900 small combines have been extended to rice farmers and there are three local manufacturers ready for the production of such machines.

Grain Dryer

A bin-type artificial grain dryer has been introduced to local farmers. It is portable, weighing about 270 kg. In the ordinary harvest time, the grain dryer could reduce the moisture content of the grain from 23 to 13 per cent and turn out about 1,500 kg of dry paddy every 12 hours. In the rainy season, the dryer could even be operated 24 hours a day. The fuel for the burner of the dryer is kerosene, while its 1/2-hp motor blower uses electricity as source of power. About 12,700 units of the dryer have been extended to local farmers for adoption. Meanwhile, some 5,400 units of circulation-type dryers of local made were also adopted by farmers as shown in Table 3. So far, about a dozen local farm machine shops are producing these dryers for local use.

In the meantime, several farmers' associations and some agencies concerned have constructed bigger dryers for commercial purposes.

Extent of Farm Mechanization

Land preparation is done by using power tillers (mostly for paddy fields) and tractors (for dryland). As for other farm operations such as transplanting, harvesting and drying, only those for the rice crop have some achievements. The extent of farm mechanization in the country by the end of 1977 is shown in **Table 4**.

Table 4. Extent of Farm Mechanization

Farm Practice	Machine Used	Number of Machines (set)	Capacity (ha/unit)	Total Capacity (ha)	Extent of Mechanization (%)
Land preparation	power tiller	56,000	10	560,000	72*
	Tractor	1,750	60	105,000	
Rice transplanting	Rice transplanter	10,500	10	105,000	27**
Rice harvesting	power thresher	7,900	5	39,500	20**
	Rice combine	3,800	10	38,000	
Rice drying	Rice dryer	17,000	5	85,000	22**

*Total capacity divided by the area of cultivated land.
**Total capacity x2 (crops) divided by the rice growing area.

Measures to Promote Farm Mechanization

The following major measures have been adopted by the Government for the promotion of farm mechanization:

Loans and Subsidy

Individual farmers or farmers' organizations are subsidized at 10 to 20 percent of the cost for buying rice transplanters, rice combines, rice dryers and other newly developed devices on condition that the machines be local-made ones.

Besides subsidies, farmers may apply for loans from the farmers' associations (FA), the Provincial Cooperative Bank, the Land Bank of Taiwan or the Farmers Bank of China to cover the remaining cost of above-mentioned machines. This kind of loaning also applies to the procurement of power tillers, tractors and attachments, power threshers, farm engines, power sprayers, etc., for the entire cost. Repayment of the loans is made in six to 14 installments over a period of three to seven years, depending on the amoun of loans. The interest on loans is 8.5% per year.

Rice Nursery Centers

The use of rice transplanters needs specially raised rice seedlings. It is not economical in both time and cost to raise rice seedlings individually. The operation of rice nursery centers has the advantages of 1) simplifying the farmer's field work; 2) saving labor and cost; and 3) improving seedling-raising techniques. Also, the farmer may apply to the Government for a 25% subsidy in setting up a rice nursery center capable of providing rice seedlings for at least 100-ha paddy fields. So far, there are more than 350 rice nursery centers in the country. The Government is going to continue this program for the coming years in order to accelerate the mechanization of rice transplanting.

Farmers' Training

Development of suitable machines for local use is not enough. It is necessary to teach farmers how to operate the machines and maintain them in good condition so as to lower the fixed and operating costs. This kind of training is conducted island-wide by two junior colleges of agriculture and a number of agricultural vocational schools. Their courses include the operation and maintenance of engines, power tillers, rice transplanters, sprayers, threshers, rice combines, and dryers.

Under the Ministry of Economic Affairs (MOEA), there is the Agricultural Vocational Training Center which trains farmers in the operation and maintenance of rice combines and tractors.

Research and Development

Current researches are concentrated on the development and improvement of suitable planting and harvesting machines for field crops in order to solve the labor shortage problem which is getting serious year by year.

A solar energy system for drying farm products has been tested by the Agricultural Engineering Department of the National Taiwan University for two years now. Preliminary results show it to be a right direction for a new source of energy.

As indicated above, the promotion of farm mechanization covers three types of work, namely, extension, training and research. Responsible for overall planning and programming are the MOEA, the then Joint Commission on Rural Reconstruction (JCRR) now Council for Agricultural Planning and Development (CAPD), and the Provincial Department of Agriculture and Forestry (PDAF).

Besides teaching, agricultural schools also conduct farm machinery research and training programs. They include the National Taiwan University (NTU), National Chung Hsing University (NCHU), Chiayi and Pingtung Junior Colleges of Agriculture, and about 20 agricultural vocational schools.

Under PDAF, there are seven District Agricultural Improvement Stations (DAIS) responsible primarily for extension work and the Taiwan Agricultural Research Institute (TARI) and its Agricultural Experiment Stations responsible for research.

Future Outlook

On July 1, 1978, an Agricultural Mechanization Fund was set up under MOEA. A committee for management and handling of the Fund has been appointed with its members from the MOEA, CADP, PDAF, Ministry of Finance, Council for Economic Planning and Development, and the Provincial Food Bureau.

The Government will provide NT$1,000,000,000 for the Fund every year from 1978 to 1981 for an estimated need of farm machinery loan for about NT$2,000,000,000 per year. The difference will be contributed by the loaning banks and FAS with interest compensation from the Govenment's loan interest which will be mostly used for implementing the farm mechanization program.

With the Fund, agricultural mechanization would have a very bright future. The following achievements can be expected:

1. Farm machines will be improved to become more efficient.
2. Small tractors will be developed to substitute power tillers for land preparation.
3. Rice farming will be fully mechanized within ten years.
4. Practical solar energy systems will be developed.
5. Development of machinery for forestry, fisheries and animal husbandry will be raised to a higher level. ■■

Comparative Farm Returns

(Continued from page 22)

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Costs of Owning and Operating Tractors in Tharparkar District of Sind, Pakistan

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Introduction

The tractor, being the most important single item of machinery for selective farm mechanization in developing countries, requires a high basic investment. Full considerations of farm size and annual use are required to be made in purchasing a tractor of a certain horsepower along with necessary implements. The economic benefits from a tractor depend upon the efficient manner of its use. Pakistan, like many other labor intensive developing countries of the world, is moving toward a selective form of farm mechanization with the introduction of tractors as a source of farm power. Tractors are used mainly for those farm operations in which animal and human power are uneconomical, requiring much drudgery and time.

Costs have been given prime importance in making management decisions about the use of tractors and other farm machinery.

Objective

The main objective of this study was to ascertain theoverall cost of tractors on a per hour basis by individual owners, including considerations for different annual use, age of tractors, size of farms and different makes of tractors. The study was to be a guideline for optimum annual use of tractors for minimizing cost per hour. The effect of tractor age on costs should be helpful in making decisions for replacing an old with a new one at a certain age.

Survey Procedure

A field survey of tractors owned by the farmers was conducted in Tharparkar district of Sind, Pakistan during the summer of 1975. The district was selected on the basis of acquaintance of the researcher with the farmers of the area so that they would be cooperative in giving data about their tractors. According to the available secondary data there were 256 tractors in five sub-districts (talukas) of the district. The cluster random sampling technique was adopted and 47 tractors were selected after taking into consideration time and financial factors.

The data regarding the annual use and cost of tractors for the period July 1974 to June 1975 were collected on pretested proforma by contacting the selected tractor owners or their farm managers. The data were collected from the available farm records and information from tractor owners, farm managers and the tractor drivers. Out of the 47 tractors selected in the sample, 27 were found to be Bylarus (U.S.S.R.) 18 were International Harvester (U.S.A.), and 2 were Fords (U.S.A.). Except for two, all tractors were between 50 and 55 HP size. All the tractors had diesel engines.

The costs were divided into two groups: owning or fixed costs which include annual depreciation, interest, taxes and shelter charges;

operating or variable costs which include fuel, oil, lubricants, maintenance, repairs and labor costs. Annual depreciation has been calculated using the straight line depreciation method, assuming ten years life and 10 percent salvage value (Hunt 1973, and Bowers 1974). Annual interest at the rate of 11 percent, which is commonly chargeable for agricultural purpose, and taxes and shelter charges at 1 percent of purchase price are added to the depreciation, to make a single percentage of purchase price as annual owning cost.

$$D = \frac{P - S}{L} = \frac{P - .1P}{10} = 0.09P$$

$$I = \frac{P + S}{2} \times .11 = \frac{P + .1P}{2} \times .11$$

$$= 0.06P$$

Taxes and shelter = – .01P

Where:

P = Purchase price
S = Salvage value, i.e. .01P
D = Annual depreciation
L = Life, i.e. 10 years
I = Annual interest, i.e. 11 percent

Therefore total fixed cost per year is equal to 0.16P or 16 percent of the purchase price. The operating cost per hour was found by dividing annual operating cost by annual hours of use.

Summary of Findings and Discussions

The average cost per hour was U.S. $2.14 on an average annual use of 1,404 hours. The average initial cost was low due to the fact that most of the tractors were purchased before 1971 when the price was less than Rs 20,000 ($2,000) per tractor. The purchase price of a 55 hp tractor in 1974 was about Rs 55,000 ($3,500).

The average annual use of tractors was high as compared to that in the developed countries due to the reason that tractor or mechanical power per unit area was low in the district. As the demand of tractor for primary tillage, seedbed preparation, transport and threshing has increased in the area, the tractors were kept quite busy either on the owner's land or for hire work. Chancellor (1971) also reported an annual use of 1,360 hours in Thailand for four-wheel tractors.

The hourly custom-hire rate in the area was $4.00 to 4.50 per hour which is almost double the total hourly cost.

Table 1. Tractor Annual Use and Cost per Hour

Annual Use (Hours)	No. of Tractors	Cost per House (U.S. Dollars)		
		Owing	Operating	Total
Below 1,000	4	0.57	1.47	2.31
1,000–1,200	10	0.32	1.90	2.24
1,201–1,400	9	0.26	1.93	2.19
1,401–1,600	11	0.23	1.83	2.06
1,601–1,800	8	0.21	1.93	2.14
Above 1,800	5	0.16	.202	2.18

Costs Affected by Annual Use

The costs for various rates of annual use are shown in **Table 1**.

Although there is no significant correlation between annual use and cost per hour, there was a trend of reduction in cost per hour as annual use increased to 1,600 hours. The reason for this may be due to the fact that despite their old age some tractors still had a high annual rate but their repair costs were much greater.

Costs Affected by Age of Tractors

Average costs per hour for different ages of tractors are shown in **Fig. 1**. The owning cost per hour decreased as the age increased because old tractors were purchased at lower prices than the new. The operating cost excluding repairs also showed a decreasing trend as age increased. This is due to the reason that the new tractors were of the Bylarus make which had higher rate of fuel consumption per hour than the International Harvester or Ford tractors. The repair cost showed a high rate of repairs during the fourth to sixth years of use. The high repair cost per hour occurred due to general overhaulings of tractors, replacement of tires, batteries, hydraulic pumps and other major parts during this period. The repair cost decreased immediately after this period. Tractors were in good condition after general overhaul during the age of 4 to 6 years. The repair cost again increased as age increased beyond 8 years.

There was significant correlation ($r=.63$, $t=17.25$) between age of tractors and cost per hour of operation. The average relationship between age of tractors and cost per hour as shown in **Fig. 2**. After 1972 the repair cost had increased exorbitantly due to higher prices of spare parts and materials. Lack of genuine spare parts and proper quality engine and lubricating oils had also resulted in frequent breakdowns and major losses. The repair charges by service shops had also substantially increased after 1972. Three tractors in the age group of above 8 years were beyond economical life, having more than 12 years of age and the owners had spent large amounts for keeping them in working condition. Majority of tractors beyond 3 years of age were requiring engine overhauling after every year. Due to devaluation of Pakistan's currency in 1972 and the high rate of inflation, the accummulated repair cost for the tractor beyond 8-year of age has become twice the pur-

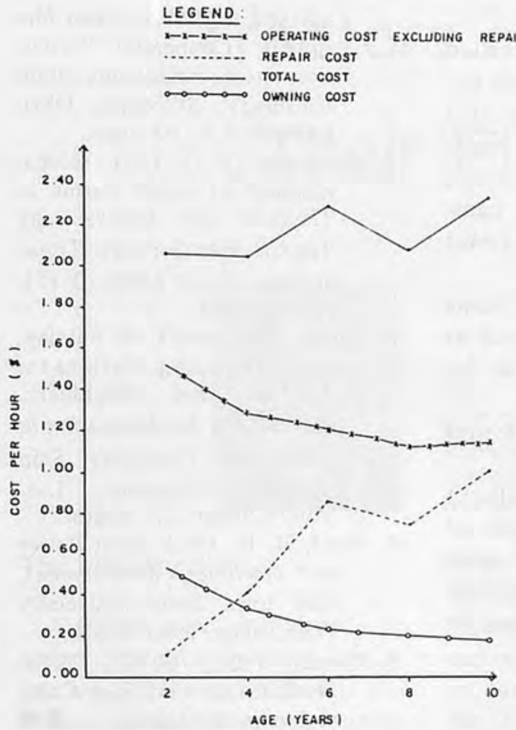

Fig. 1 Average Costs per Hour for Different Ages of Tractors

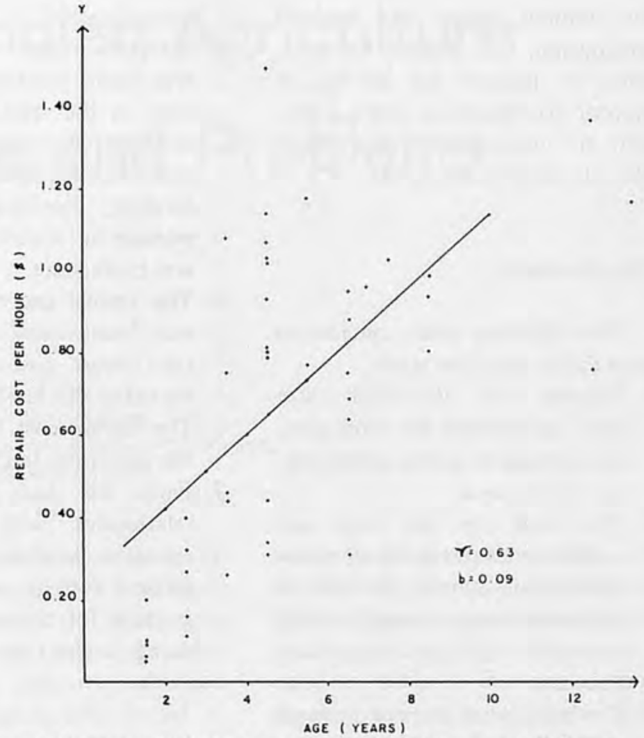

Fig. 2 Average Relationship Between Age of Tractors and Repair Cost per Hour

chase price.

It was observed during the study that replacement policy of a tractor depends upon the availability of financial resources rather than upon normal economic life period considerations.

Size of Farms and Cost per Hour

The costs per hour according to size of farms are shown in Table 2.

The smallest farm having a tractor was about 40 ha in size, and the largest farm was about 400 ha. The tenancy system prevail in the area and most of the farm operations are performed by the tenant with bullock drawn imple ments and hand tools. The tractors are used only for operations such as plowing, harrowing, leveling, transporting and operating threshers.

In Tharparkar and almost in the whole of Sind province, the tractors are owned by those farmers who have farms of 40 ha (100 acres) or more. The big farms are either family farms or include land rented by individual owners. The correlation between size of farms and cost per hour of tractors was not significant (r=–.04 and t=0.27). This was due to the fact that the size of the smallest farm was sufficient for optimum use of a 55 Hp tractor. Tractor owners realized the benefits of increased annual use and, therefore, small farmers used their tractor frequently for hire work.

Table 2. Size of Farms and Tractor Costs per Hour

Farm Size (ha)	No. of Tractors	Average Annual Use (Hours)	Percent Time Used for Hire Work	Cost per hour $		
				Owing	Operating	Total
Up to 100	7	1,428	51	0.33	1.90	2.20
101–200	22	1,353	10	0.33	2.14	2.47
201–300	10	1,435	0	0.27	2.00	2.27
Above 000	8	1,481	0	0.25	1.85	2.10

Other Factors Related to Cost

The majority of the Bylarus tractors werd purchased after 1971. All International Harvester and Ford tractors were old models purchased prior to 1972. As reported by the farmers, all three makes were equally successful in the area. Average cost per hour for three makes was almost the same, i.e., from U.S. $2.00 to $2.18.

The tractor – drawn implements owned by the farmers were recorded and the annual use of tractors for various farm operations was also determined through interviews with farmers and tractor drivers. A trailing type double-action disk harrow (14–16 disks, locally manufactured) was the implement commonly owned by all the tractor owners. Tractor trailers were owned by 90 percent, disk plows by 47 percent, levelers by 70 percent, cultivators by 34 percent and threshers by 48 percent of the tractor owners. As an average, 61 percent of the annual use was made for primary tillage and seedbed preparation, 16.5 percent for transport, 12 percent for leveling, 8 percent for threshing and 2.5 percent for miscellaneous operations like pumping, spraying, etc.

Conclusions

The following main conclusions were drawn from the study.

1. Tractors of 50–55-HP size were appropriate for farm sizes, soil conditions and cropping pattern of the area.
2. The total cost per hour and custom-hire rates per hour showed that the owners of both old and new tractors were making reasonable profits from their tractors.
3. The benefits of increased annual use had been realized by the tractor owners and they were not keeping their tractors idle unnecessarily.
4. Selective farm mechanization was being practiced in the district as the tractors were used for high power consuming operations like seedbed preparations, leveling, threshing, and transporting for which bullock power was inadequate.
5. The annual use of 1,600 hours was found most economical as the lowest cost per hour occurred at this level.
6. The repair cost increased with the age of the tractors.
7. Farm size had no significant relationship with the cost of tractor operation as the small farmers (40 ha) also used their tractors for optimum hours by doing custom hire work.

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Tractors in Indian Agriculture —Their Place and Problems

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The Industry Size

Tractors were introduced to Indian agriculture in early 20s. It was only in the early 60s that the indigenous production of tractors commenced. The indigenous tractor industry, therefore, is yet to complete its second decade. There are at present nearly 400,000 tractors in use in the country. State-wise population figures are given in **Table 1**. Punjab leads with nearly 70,000 tractors, followed by Uttar Pradesh with 61,000. Taking into account the area under cultivation in each state, hectares cultivated per tractor work out to 69 in Punjab as against 2,463 in West Bengal. National average is 473 hectares per tractor.

Table 1. State-wise Population of Tractors

State	Tractor population (as on 31st March 1977)
Punjab	68,762
Uttar Pradesh	60,748
Haryana	38,036
Rajasthan	21,861
Gujarat	15,664
Madhya Pradesh	14,976
Tamil Nadu	14,075
Maharashtra	12,842
Andhra Pradesh	12,588
Bihar	12,447
Karnataka	11,093
Kerala	2,529
Orissa	2,397
West Bengal	2,250
Assam	1,562
Jammu & Kashmir	1,191
Himachal Pradesh	790
Others	x4,862
Sub-total	2,98,610
Addition in 1977–1978	41,838
Estimates of addition during 1978–1979	50,000
Present estimates of tractor population (31.3.1979)	3,90,448

Source: Ministry of Agriculture & Irrigation, Government of India.

The tractor industry is reasonably well established. Eleven makes of tractors, most of them with foreign collaboration, offer 18 models in size 19 to 75 h.p. The price varies from Rs. 27,500 for a 19 h.p. tractor to Rs. 147,367 for a 75 h.p. tractor (**Table 2**).

The present annual demand is estimated at about 60,000 units and in spite of the environment which is not very favourable, the demand may rise to 70,000 units in 1981. Progress on indigenous production during 1961–79 is indicated in **Table 3**. The annual production has increased from 880 units in 1961–62 to 55,196 in 1978–79.

In 1950 there were only 8,000 tractors in use. There were bitter critics of the tractor and most of them, including politicians and policy makers, saw no place for tractors in Indian agriculture. In spite of these critics, compulsions of agriculture have increased the tractor population from 8,000 to 400,000 in 29 years.

There has been an investment of over Rs. 600 million in the 11

Table 2. Prices of Indigenous Tractors

Make	Model	H.P.	Price (as on 1-5-79) Rs.	Rs. per H.P.
Eicher	Goodearth	26.5	34,360	1,297
Escorts	E-535	35	47,787	1,365
Escorts	E-3036	35	51,742	1,478
Ford	3600	46	68,681	1,493
Harsha	T-25	25	46,822	1,873
H.M.T.	2511	25	44,668	1,787
	Zetor 5711	55	64,653	1,176
Hindustan	Super	50	57,800	1,156
International	B-275	35	52,000	1,486
International	444	45	57,050	1,268
Kirloskar	D-4006 K	43	65,215	1,517
Kirloskar	D-6006 K	75	1,47,367	1,965
Pittie	4000	35	45,350	1,296
Swaraj	724	24	46,630	1,943
Swaraj	735	35	50,015	1,429
Swaraj	Sartaj	19	27,500	1,447
Tafe	MF-1035	35	53,911	1,540
Tafe	TAFE-504	50	62,702	1,254

Table 3. Indigenous Tractor Production

Year	Quantity
1961–62	880
1962–63	1,414
1963–64	1,983
1964–65	4,323
1965–66	5,714
1966–67	8,816
1967–68	11,394
1968–69	15,466
1969–70	18,120
1970–71	20,099
1971–72	18,100
1972–73	20,802
1973–74	24,425
1974–75	31,088
1975–76	33,252
1976–77	33,146
1977–78	40,946
1978–79	55,196

manufacturing plants. The industry directly employs 65,000 persons but the number of workers directly and indirectly engaged exceeds 1.2 million, and the total population supported by the industry is 7 million. The total output of the industry for tractors, implements, accessories and spare parts is estimated at about Rs. 400 million a year. Estimates of investment made in 4 lakhs 400,000 tractor units in use works out to a collosal figure of over Rs. 16,000 million.

Why Tractors

In spite of the industry's growth, questions are again being asked as to why we need tractors. There are four main reasons and we will examine each one of them:

1. Adequacy of power input;
2. Accuracy and timeliness of farm operations;
3. Removal of drudgery; and
4. Improving production and productivity and reducing cost of production.

Power Input

A worldwide study has concluded that for optimum yields, there is a need for a power input of at least 0.8 h.p. per hectare. Our power pack comprises 66 million bullocks, 400,000 tractors, 30,000 power tillers, 5 million pump sets and some other equipment like power sprayers, etc. The installed horsepower on our farms works out to only 0.4 h.p. per hectare. For our double cropping and intensive agriculture, we should aim at one h.p. per hectare (Japan has 3 h.p. per hectare and most of the countries in Europe and America 2 h.p. per hectare). How do we multiply the power input 2½ times? By raising more bullocks?

Farm Operations

For increasing production and productivity it is important that the farm operations are done accurately and timely. Accuracy and timeliness have become more critical for high yielding varieties of crops. With multicrop seasons, time available for harvesting the crop and the seedbed preparation for the following crop is limited – 4 to 6 weeks. During these peak seasons, there is an acute shortage of labour. Delayed sowing and harvesting both result in loss of production. Seed has to be sown at a proper depth and fertiliser applied at the correct place. How do we ensure better accuracy and timeliness of the farm operations? Farm mechanization means a better job faster.

Drudgery

Agriculture has always demanded a dawn-to-dusk work day. When the land was flowing with "milk and honey", food grains and ghee were within easy reach of the farm labourer and he enjoyed good health. Hard and long working hours presented little problem. Under today's conditions of farming and the health of the farm labour, absenteeism has considerably increased. A major cause for migration of farm youth from rural to urban areas is the drudgery of work in the farm. Must we not provide relief whereever possible from the drudgery, while at the same time aim at better productivity and higher yields?

Farm Productivity

Several studies have shown that with the use of tractors, cropping intensity can be increased. This naturally results in higher tonnage of produce per hectare per year. In turn, it calls for more gross man hours during the year. When farm operations are performed accurately and timely, crop yields are higher resulting in better returns to the farmer and more foodgrains to the nation. Proper use of tractors and their maximum utilisation should also result in lower cost of production. Because of our half-hearted approach to mechanisation, the impact of reduction in the cost of production has not been felt to the extent possible.

Fallacy

There are two popular fallacies on tractors. One is in regard to displacement of labour. Without entering into much argument, let us only look at the case of Punjab. With greater use of tractors, labour is still in short supply and wage rates are the highest in the country. Under certain conditions, there may be intially some marginal adjustment of labour, but taking a long-range view, use of tractors will certainly result in higher production, better cropping intensity and, therefore, logging of more man-hours per year.

The other fallacy is that the tractor will only benefit the 'large' farmer. To some extent this may be true, but the benefits of mechanisation can be taken to the small farmer as well, if we organise the entire system properly. During the season, because of the pressureon labour and bullocks, wage/hire rates are high and neither labour nor bullocks may be easily available. By greater use of tractors on our large farms, pressure will be relieved on these two inputs and their availability will considerably improve for the small farmer. By properly organising custom hiring of tracotrs, the benefits of tractor farming are being extended to smaller farms.

Table 4. Operational Agricultural Holdings

(Percent)

Holding Size	Area (ha)	Number	Area Under Cultivation
Small	Up to 4	85	40
Medium	4 to 10	11	26
Large	More than 10	4	34
		100	100
	Total	70.5 million holdings	145 million hectares
Area under irrigation			47 million hectares

The Three-Tier Agriculture

Irrigation precedes mechanisation and leads to agricultural prosperity. To ensure maximum utilisation of the irrigation potential, the land must be levelled and proper levels maintained all the time. Irrigated farming permits growing cash crops, some of them so important to our commerce and industry, like cotton, sugarcane and groundnuts. Returns from these farms are better and cost benefit ratio, more favourable.

I am with the critics on one score that we should take a selective approach to mechanisation. We should take mechanisation first ot irrigated areas and so called 'large' holdings. Benefits will certainly accrue to other sectors of agriculture as well, including dry farming and small holdings. Let us look at the holding pattern in Table 4. Eighty-five percent of holdings are small and the area they cultivate is 40%. Though the number of holdings are important and are of direct interest to the politicians, we cannot lose sight of the area under cultivation under different sizes of holdings.

We must accept the 3-tier concept of agriculture and our policies must aim at improving the productivity for each of these three categories. In the case of the textile industry, we have accepted the handloom, powerloom and the textile mill. Why can't we accept a similar 3-tier pattern in our agriculture for good, rather than shedding "crocodile tears" on the lot of the small farmer? They have to be given their due attention but the programme for them has to be more meaningful and the solution may not lie in technology alone.

The so called 'large' holdings are not really large by any standard. There are 2.8 million of such holdings of 10 hectares each and above covering an area of 50 million hectares. Their needs for the type of prime mover are certainly different.

Problem Areas

We have yet to derive maximum advantage from the use of tractors. There are problem areas and let us examine them one by one. The most important problem is the *Training* of operators (be they self-employed or hired) in proper operation, maintenance and repairs of tractors. Training is also essential for the mechanics in proper repairs and overhaul. A large number of such workshops and way-side garages have now cropped up where the mechanics are untrained and the workshops ill-equipped with tools. This is resulting in substantially higher costs and time loss.

With the present annual demand of 60,000 tractors, we need at least 60,000 operators. Meagre facilities for such training are available at Budni (MP) and Hissar (Haryana) and they train about 400 persons a year. Training is required on a mass scale. It will also considerably reduce the number of farm accidents. Training in tractor driving is not enough. Equally important is the use of implements, their proper adjustments, hitching and selection of soil working components to suit a wide variety of operating conditions. There is an urgent need for establishing a *National Institute for Training in Agro-Industrial Services* (NITA). To begin with, we must train trainers and produce audio-visual training aids.

We must ensure unrestricted availability of unadulterated *fuels and lubricants.* All tractors being used operate on diesel. Diesel engines are quite sensitive and require to be handled with care. Fuel injection pump repairs are expensive. Because of the prevailing dusty conditions, the tractor user must be prperly briefed in refuelling tractors. Deterrent punishment must be meted out to adulterants of fuels and lubricants and manufacturers of spurious and poor quality spare parts. It is estimated that sales of fuel and lubricants for farm prime movers are of the evel of Rs. 3,000 million a year. Yet this sector has hardly received its due attention from any of the five nationalised oil companies. Why can't we have a *Farm Fuels Advisory Service*?

Underwriting services (insurance) have also been neglected. It is estimated that the General Insurance Corporation mops up annually insurance premia of over Rs. 40 million a year on tractors alone. Yet there is hardly any service available to the farmer except the conventional policies. Does not the farmer deserve a better service? Should we not offer him a composite insurance for the equipment, the owner and the driver of the tractor? Should the tractor not have a special low premium under a package policy during its first year from the factory to the farm? Should the GIC not take a meaningful interest in spreading *safety consciousness* among the rural folk?

It took several years of goading for the GIC to offer Rs. 25 per year policy for pump-sets. Why can't more items be covered in a similar manner, in particular the bullock cart and the tractor – trailer?

Operator safety should also be kept in view, particularly in such areas as:

(i) *Exhaust fumes* – The exhaust pipe should direct the fumes away from the operator. The operator should get his lungs checked from time to time.

(ii) *Vibrations* – There are violent vibrations on the tractor because of the terrain. Normal pan type seats are outmoded and uncomfortable. Cushion seats with s shock absorber should be used to ensure that the operators do not suffer from slipped disc and other problems of the spinal column.

(iii) It is advisable to provide a canopy on the tractor not only to provide protection from weather but also to protect the driver in case of an overturn. In many countries of the world, fitting of canopy on the tractor is now compulsory under the law.

(iv) Noise from the tractor is above tolerance level. On the one hand, operators should get their ears checked regularly, and on the other manufacturers should muffle the noise to a safe level.

There is lot of room to improve *after-sales services* on tractors. The industry, the dealers and the unorganised sector of mechanics can do a lot to improve the utilisation of the tractor and reduce its cost of operation. Certain spare parts have been continuously in short supply. With a large tractor population, the spare parts trade has increased but unfortunately spurious low quality parts manufacturers seem to have become more active. The farmer needs an entire gamut of services starting with selection of proper equipment, training on operation, maintenance, repairs and storage, warranty services and the necessary after-sales services.

At present the range of *implements* being offered is really confined to tillage items like ploughs, cultivators and harrows. Trailers, too, are available. Gaps in mechanisation include suitable equipment for sowing, inter-cultivation and harvesting. The industry has to takemore meaningful interest in *R & D*. There has to be better liaison between the academy and the industry. There is a need for a small 18 to 20 h.p. low-priced tractor at about Rs. 20,000 lack.

The *prices* of tractors are rather high. On the one hand, industry and trade should examine the prices and explore the avenues where prices could be reduced. On the other hand, the Government must be bold and completely exempt tractors from all taxes and levies on an experimental basis, say, for a period of five years. Taxes amount to 35 to 40 percent of the cost of tractors. It is estimated that the Central, State and Local Governments collect more than Rs. 2,000 million a year on tractors through imposition of taxes and levies. It must be realised that all these are passed on to the farmer in any case and it adversly effects his cost of production.

Almost all tractors being bought today are *financed* under various schemes and most of the money comes from the commercial banks. Theoretically, credit loans are easily available but in practice the procedure is cumbersome and time consuming. Tractor priority also seems to have been down-graded on a wrong assumption that it does not benefit the small farmer. The entire package of financing systems and services, including logistics, needs to be looked into with a view to improving its efficiency.

In sum, the tractor has an important place in our agricultural economy. We should take a selective approach in popularising tractors for conditions where its utilisation will give the most favourable cost benefit ratio. Tractor owners must use the equipment properly and ensure maximum utilisation of the heavy capital investment in tractors, implements and accessories totalling Rs. 60,000 to 100,000 per unit. It is a useful prime mover on our farms. Its use will improve the power input and result in higher crop production. At its present level of population, it does not hold any threat for displacement of labour. In fact, it is providing the much needed supplementary power on the farm. There is lot to be done by the industry and trade, Government and research institutions for better utilisation and ensuring maximum benfits from this mode of energy for farming-operations. ■■

Standardization and Quality Certification of Farm Machinery and Power: Perspective and Challenges

by
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Introduction

Farm power and machinery industry caters to the needs of the farming community of the country which provides food and fibre to our vast population. This industry assumes a special importance in the wake of the green revolution. Since farm equipments contribute to increased production in three major ways (timeliness of operation, improved quantity of work and reducing the drudgery and physical exertion of workers) this has, therefore, resulted in an enormous volume of trade. The development of all the areas of this industry needs to be geared to scientific and systematic lines in a coordinated manner to cope with the demand. Standardization plays an important role in coordinating the efforts for integrated and speedy development of the industry.

Standardization is the process of formulating standards. It is often said that the process of development of national standards is basically the process of coordinating the three interests represented by producers, consumers and technologists. In this attempt for coordination, standards organizations like the Indian Standards Institution try to secure a delicate balance among the three ensuring that the standards are based on the current state of scientific knowledge, permit production at economical level and serve the needs of consumers, in general. The development and growth of this coordinated approach to standardization is often a useful technical expertise for efficient mobilization of resources in a country.

Standard serves as a tool for quality control and quality certification. To quote John Ruskin, "quality is never an accident. It is the result of intelligent effort. There must be the will to produce a superior thing". In manufacturing a product certain controls are required to be excercized at all levels be it design, process or finished product. The process of quality certification is in fact a guarantee given by a third body, besides purchaser and seller, regarding the built-in quality of the product. The quality certification is of greater importance in farm machinery since the efficient utilization of other agricultural inputs is dependent on the machinery as this is the "input of the inputs."

Standardization Efforts in India

Prior to 1946, India had no national standards organization to cater to the needs of the country and the Instituton of Engineers (India) acted as the Indian Committee of the British Standards Institution. In pursuance of a Resolution of the Government passed in September 1946, the Indian Standards Institution (ISI) was established in 1947 the year in which India became independent. The Institution was assigned with the responsibilities of preparing and promoting standardization and quality control at national level. Besides, ISI was authorized to liaise with other international organizations dealing with standards, such as ISO and IEC.

The formulation of Indian standards is carried out through various technical committees. The standards are evolved in a very systemat-

* The paper was presented at the annual convention of the Indian Society of Agricultural Engineers held in December, 1978.

ic manner and a detailed procedure is followed. In the beginning a proposal for the formulation of standard on any specific subject has to be received from any member of the ISI or any authority or body. If as a result of investigation and screening, the need for the standard is established, the work is entrusted to a technical committee comprising of experts drawn from the industry, technologists, research and testing organizations, consumer bodies and the government officials engaged in the promotion of the concerned activity. The committee explores and studies the subject and prepares the draft. If necessary, the matter is entrusted to a subcommittee or a panel for initial work. The draft thus prepared is discussed by the committee and circulated for comments in India and abroad. Wide publicity is given to the draft standard not only by this way, but at the same time the users are specially asked if they are likely to ace any difficulty in implementing the standard when finalized. The comments are considered carefully and the draft is finalized in such a manner, as to ensure the largest possible agreement. The finalized draft is edited and referred to the concerned Division Council for adoption as an Indian Standard. The adopted standard is printed, gazette notified and given publicity to the interests concerned for their implementation. All the standards, which are 5 years old or more, are reviewed for their re-affirmation, revision or withdrawal.

Standardization of Farm Machinery

Following the recommendations of the conference on production, distribution and popularization of improved implements organized by the Indian Council of Agricultural Research (ICAR) and at the instance of Ministry of Agricultural Research (ICAR) and at the instance of Ministry of Agricultures, the ISI set up the Farm Implements and Machinery (later renamed as Agricultural Machinery and Tractors) Sectional Committee in 1959 under the Agricultural and Food Products Division Council. Since then, an organized attempt has been made in the development of standards in this field. Due to increase in work and also for expediting the areas of immediate importance the work has been divided lately among 6 sectional committees:

Agricultural Produce Processing Equipment, AFDC 42;
Crop Protection Equipment, AFDC 43;
Horticultural Equipment, AFDC 44;
Soil Working Equipment, AFDC 50;
Harvesting, Threshing and Transport Equipment, AFDC 51 and
Agricultural Tractors and Power Tillers, AFDC 52.

The work on engines, pumps and electric motors for use in agriculture is being looked after by other departments of ISI.

The Indian standards were first equipped to be compiled on manually operated and bullock drawn implements, as the indigenous industry of agricultural machinery started with the premise that only such implements produced in larger number would meet the growing requirement of agricultural development. But this premise did not hold good for long and soon a large number of tractors had to be imported. Subsequently, the plans were finalized for indigenous production of tractors which is now of the order of about 40,000 units per annum. The farmers also started using engines, pumpset and other sophisticated machines. The ISI was equipped to produce standards for all such items. Thus standardization activity was geared to the changing needs of the industry and moved parallel with the development and usage of various agricultural machinery in the country. Throughout the process of formulation of standards, the areas of immediate importance were given a high priority.

Basic Standards

These are standards of general application and of paramount importance. Standards on atmospheric conditions for testing, drawing codes, SI units, preferred numbers, inter-conversion and rounding off numerical values, guide for drafting standards, etc. have already been prepared by various departments of the ISI. In addition, the following standards directly related to agricultural machinery were also brought out:

Glossary of terms – In order to provide the authentic definition of the terms most commonly used in relation to farm implements and machinery not only for the people engaged in the profession of agricultural engineering but also to others the IS 7015–1972 (Glossary of terms relating to farm implements and machinery) was formulated. Later detailed terms were included and defined in the areas of crop protection, tractors, dryers, and combines by way of issuing separate standards.

Sampling – The evaluation of the quality of a lot of manucactured products with a view to determining their acceptability is a major problem with the consumers. For this purpose inspection has to be done either on all the items in the lot or a sample. The former, usually referred to as 100 percent inspection, becomes quite an uneconomical method especially in the case of large lots; in certain cases, like destructive tests, it is not to be conceived at all. The second method, that is sampling inspection, is more paractical, quick and economical. In view of this the IS: 7201–1974 (Methods of sampling of agricultural machinery and tractors) was publicized.

Symbols for operator controls – The use of symbols eliminates the language barriers as it enables operators to identify and understand the functions of different controls thus eading to better handling and operation of the machines. Besides the symbols, their location in the machine and methods of operation is equally important and complementary to each other. The IS: 6283–1971 and IS: 8133–1976 help in bridging this gap.

Operators' manual – The machinery manufacturers are publishing manual and other literature for the guidance of the operators and users. Different manufacturers are using various patterns for presentation of the literature. It is intended that IS: 8132–1976 would provide guidelines for bringing out these publications on a uniform basis for easy and proper understanding by the operators and users.

Installation and preventive maintenance – In order to derive maximum benefits from machines, to obtain trouble free service and safe operation of the machine, preventive maintenance and installation is of great help. An attempt has been made in this direction and the IS: 6840–1972 and IS: 6847–1972 covering preventive maintenance and installation of tractors have been publicized. A draft relating to power threshers is presently in wide circulation and work on combine harvesters is on the way.

Custom-hiring – With the increasing emphasis on custom services of farm machinery in the country, estimation of cost of operation in a standardized way has assumed considerable significance for planning and management. A need was, therefore, felt to prepare a standard on the subject. A draft guide for estimating loss in farm machinery operation has been finalized for publication.

Product Standards (specification)

The exact and precise prescription of quality in terms of technical requirements is a standard specification. A specification normaly prescribes terminology (specific to the product), raw material, dimensions and designs wherever necessary, performance and their method of test. This is the type of standards on which quality certification is possible. While preparing these standards efforts should be made to keep this in view. Standards on most manually operated and animal operated equipment and their interchangeable and fast wearing components have been publicized. The standards on some of the tractor- and power-operated equipments, such as disc harrow, cultivators, seed-cum fertilizer drills, power thresher, power maize sheller, sugar cane crusher, and power sprayers have also been publicized. The standards on some of the linkage components of tractors such as the three point hitch, power take-off, linch pin and ball and socket assembly re also available.

Methods of Test

Standards on this aspect, important for different procedures and proformae for evaluation of performance of gricultural machinery, pose difficulty when data are collected and analysed for rational and uniform evaluation of their performance before their introduction or purchase. To solve this problem and to collect reliable data on performance characteristics, a definite need was felt for formulation of test codes, including requirements for test apparatus, test conditions, detailed procedure and proformae. Methods of test for a particular requirements are also included in the product specification. The test codes on air screen seed cleaners, tractors, plough, harrows, seed-cum-fertilizer drills, paddy weeder, power thresher, maize sheller, chaff cutter, sugarcane crusher, paddy cleaners, and sprayers have already been publicized. Work on combine harvester, paddy dehusker, grain dryers and power tiller is in progress.

Since the performance of an implement is influenced by the type and properties of soil, it was felt that the soil parameters affecting the performance should be judged as accurately as possible. In order to fulfill this need, an Indian Standard IS: 7926–1175 (classification of soil for testing of agricultural machinery) has also been brought out.

Standards on Safety and Comfort

The increased use of farm machinery, specially power thresher, also caused a chain of accidents of farm workers resulting in their temporary or permanent disability. This brought to the fore the need for some measures to safeguard the farm workers against voidable accidents be it due to any of the vulnerable factors of machine, man, etc. As a number of reports of many farm workers, specially the young, losing their limbs poured in, the urgency to provide for safety requirements became more pronounced. The IS: 6320–1971 (Specification for wheat power thresher, hammer mill type) has been amended to incorporate detailed provisions of safety. A draft standard covering the details of safety in manufacture of all types of power thresher has been issued for comments. In case of tractors and combine harvester, the noise, vibration, etc. affect the efficiency of the operator. Initially the method of measurement of these characteristics have been included in the test code. The data obtained would help in stipulation of limits.

Economic Benefits of Standardization

One of the important aspects of standardization is variety reduction which makes possible mass production of a given type and size of an item and in this regard attempt had been made to introduce mathematical analysis. The extent of cost reduction through variety reduction was worked out by a French expert, Mr. Albert Caquot, past president of the French National Standards Body (AFNOR) and on the basis of his experience has evolved a formula according to which, the unit cost of an article in mass production varies inversely with the fourth root of the number of the articles produced in a single run. If a number of article produced in a continous series is doubled the cost of the article will come down by 15 percent.

Maxcy and Silberston and Matsura (Japan) have also worked out the mathematical formula and arrived at somewhat similar results with those of Caquot.

In the U.S.S.R. the economic effect from utilization of products made as per GOST 1719–1973 'Double disc plough shares' at a State farm in 1973 was estimated and it was observed that annual economy amounting to 2.46 thousand roubles could be achieved. In India, the Ministry of Agriculture (Department of Agriculture) conducted a study on the disc manufactured in accordance with the IS: 4366 (Part I)–1972 and observed that 32.3 percent economy could be achieved by implementing the standard and raising the production from 20,000 to 300,000 discs per annum.

Implementation of Indian Standards

Publication of a standard is not the end of the standardization process; it is rather the beginning of a new phase, in which the standard is put to the test for practical application. In order that the standards become acceptable to all, care is taken to consult the industrialists, technologists, scientists, government agencies and consumer interests to safeguard the interest of all concerned with them taking into consideration at the same time corresponding international and the standards of other countries for similar items. Government agencies both at the State and at the Centre can play an important role in securing the implementation of Indian Standards by virtue of their function in regulating production and utilization.

No standard is ever perfect as publicized. It is only through actual use that difficulties appear- a lack of clarity here, or an anomaly there. Technological development has implications for particular provisions – new materials or new processes call into question some of the specified construction features or properties; or new test methods open the way to more performance oriented testing specification. The important thing is that the experience gained through the use of the standard be fed back into the standardization process. The anomalies or problems of interpretation or provisions is appropriate in light of new technology can be brought to the attention of the committee originally responsible for the standard.

Quality Certification

For ensuring practical utility of the standards to the consumer and purchaser and for providing third party guarantee of the quality in accordance with an Indian Standard, the ISI under the power vested in it by the provisions of the ISI Certification Mark Act 1952, passed by the Parliament, as subsequently amended, and the rules and regulations made thereunder, grants licences to the manufacturers/processors for the use of ISI Certification Mark in respect of those articles which are manufactured or processed in conformity with the requirements of relevant Indian Standard. ISI Certification Mark Scheme is a non-profit making and self-supporting scheme. To meet the expenditure incurred in carrying out its activities fees (calculated on the basis of standard practice) are levied from the parties who want to put the ISI mark on their product.

Any manufacturer having the requisite production and testing facilities may apply for a license under the Scheme, and the Institution may authorize him to apply for ISI Mark on his products after satisfying the requirements. On receipt of an application, the Institution organizes an inspection of the manufacturer's work to make an appraisal of the controls exercised during production; and the facilities available for carrying out tests on raw materials, inprocess stage of production and on the final product. After the Institution is satisfied that the manufacturer is capable of producing goods to relevant Indian standards on a continued basis, he is given a licence to apply for the ISI Mark on his products. Every license includes a scheme of testing and inspection, which licensee has to follow strictlly.

During the effectivity of the license, the Institution takes steps to ensure that the goods bearing ISI Mark have been produced in accordance with the provisions of relevant Indian Standards. This is ensured through:

a) Regular and surprise inspections of the licensee's works by the Institution's qualified inspectors to take random samples of the products for being tested in ISI and other independent laboratories. Also, records of the tests carried out by the licensee are checked in accordance with he testing and inspection scheme drawn up by the Institution.

b) Goods bearing ISI Mark are purchased by the Institution from the market and tested in ISI and other independent laboratories.

c) Complaints from purchasers and consumers about the quality of ISI marked products are entertained and looked into; free-of-cost replacement is arranged in respect of sub-standard items, if any.

Results of tests carried out on ISI marked products by the licensee, on the one hand, and in the ISI and other independent laboratories, on the other, must correspond to a satisfactory operation of the quality control system. If they fail to do so, causes are investigated and action taken against the licensee as provided under the ISI (Certification Marks) Act and the Rules and Regulations framed thereunder. For *bona fide* mistakes, corrective steps are taken and the marking is suspended till improvement in the operation of the system is ensured.

The following products relating to agricultural machinery and allied items have been covered under ISI Certification Mark: compression knapsack sprayer, pressure retaining and non-pressure retaining type; hand rotary duster, shoulder – mounted type; charge pump for pressure retaining sprayer; stirrup pump sprayer; foot sprayer; rocker sprayer; continous knapsack sprayer, piston type; atomizer type sprayer; dust applicator for burrows; spray nozzles; cut-off device; agricultural disc; rotary paddy weeder; centrifugal pump; diesel engines; electric motors; and spray lance.

ISI Certification Marks Scheme is operated on a voluntary basis, i.e., only those manufacturers who desire to bring their products under ISI certification get in touch with ISI. However, purchasers/consumers, specially in the organized sector, can play an effective role in influencing the manufacturers for producing goods conforming to standards. For instance, the Plant Protection Directorate has instructed the various State Directors of Agriculture that, as far as possible, they should purchase pest control equipment which conforms to the relevant Indian Standards. Similarly, the Directorate General of Technical Development issued instructions to all the manufacturers producing discs in the country that they should produce the discs conforming to the corresponding Indian Standard. An interesting situation arose when banks started giving loans for the purchase of centrifugal pumps, diesel engines and electric motors. To be more sure about the recovery of loans, the banks wanted that the farmers should purchase only good quality equipment. An easy solution was to issue administrative instructions that loans should be given only to those farmers who purchase centrifugal pumps, diesel engines and electric motors as certified by the ISI. This immediately led most of the manufacturers to join ISI Certification. It would thus be seen that besides technical soundness of a standard, suitable administrative decision by purchase authorities and organized consumers goes a long way in quality production, better implementation of standards and their certification of products by organizations like ISI.

International and Regional Standardization

The subject of agricultural machinary was first considered for standardization in 1929 at the international lelvel by the then International Standards Association by setting up a technical committee ISA/23 with the Secretariat in Germany. The committee had two meetings in 1930 and 1931 at the Hague and Copenhagen, respectively. Due to World War II the work of the committee came to a close.

With the creation of the International Organization for Standardization (ISO) in 1947 the subject of agricultural machinery was alloted to ISO/TC 23 with the Secretariat at Portugal and the subject of tractor was alloted to the ISO/TC 22 – Automobile with the Secretariat in France. In order to have better liaison with the work of tractor and agri-machinery in 1971 it was decided to merge ISO/TC 22T with ISO/TC 23 and Tractors (Now renamed as Tractors and Machinery for Agriculture and Forestry) Technical committee with the secretariat in France. There are 18 subcommittees dealing with various aspects.

Regional standardization in the field of tractors was attempted by the then Organization of European Economic Cooperative (OEEC) which issued tractor test code in 1959. Later this was endorsed by Organization for Economic Cooperation and Development (OECD). This organization has presently limited its work only to tractor testing.

The standardization on tractors has also been attempted by the Pan American Standards Commission. For the ESCAP region the standardization was attempted by Asian Standards Advisory Committee (ASAC), and India made an effort to set up a working group on agricultural machinery in ASAC. However, it appears that this body is not very active. A renewed attempt is being made for standardization of agricultural machines at the ESCAP region under the newly created RNAM (ESCAP Regional Network on Agricultural Machinery).

Task Ahead

For accelerating the pace of standardization and quality certification in this field certain steps are required to be taken on priority basis by the people engaged in the profession in any capacity and at any level. Some of them are given below.

Raw Material

It has been reported that specified grades of raw material, specially high carbon steel in desired amount at economical rate are not available, particularly for small scale manufacturers whereas this industry is mainly located in the small-scale sector. As a result where high carbon sheets or plates have been specified in a standard most of the manufacturers are using mild steel. For the sake of the quality of the product it was not possible for the committee to agree on lowering down the quality of steel. This situation is posing difficulty in large scale quality certification of components. A concerted effort is required by various organizations to solve this problem. It is suggested that the Society of Agricultural Engineers should make a detail study of the problem and should submit a fresh report as has been done in past when the bottlenecks of the industry were studied by the society.

Testing Facility

Quality certification is done by testing the finished product in a recognized laboratory by the certifying agency and quality control excercised by the manufacturer in the process of production. A quality conscious manufacturer should posess all the whether or not he is covered under cetification. But this aspect is lacking in this industry. Even sufficient testing facilities to test the provisions of Indian Standards are not available in the country for testing some of the products, specially plant protection equipment. Lack of adequate testing facilities slows down the process of quality certification. It is hoped that testing facilities would be created by the Indian Council of Agricultural Research and Ministry of Agriculture.

Simulation of Field Conditions

For better appreciation of the performance of soil working equipment, the equipment must be tested in field. Little efforts have been done in quantification of quality parameters from field tests. Test reports leave the purchaser to judge the performance under his condition. Non-availability of information quantifying the quality based on he simulated field conditions in the form of laboratory tests or in the soil bins pose a problem in standardization. The Central Institute of Agricultural Engineering may bridge this gap.

Synthesis of Research and Standards

Feed back information on a product resulting from field research is important for standardization. After modification or designing a product and the field performance evaluation, the engineering aspects such as size and type of material based on forces affecting various components need elaborate study by research bodies. Even after publication of a standard comparative study of the non-standardized and standardized product would help the process of standardization. A recent study conducted at the G.B. Pant University on sickles shows that the force required for cutting the crop is minimum when serrated sickles as per Indian Standard is used compared to local made and even to the Japanese makes. This is a good beginning and should be followed by others.

Study of Quality Parameters

In some products standards have been prepared mainly on the basis of performance criteria which were to be tested with crop. The equipments are manufactured and sold prior to the operational season. Under this situation it is difficult to procure the crop with desired characteristics for routine testing of the product at the manufacturer's level for the prupose of quality certification. In view of crop limitation certain other quality parameters are required to be included in the standards which will ensure the performance without actual testing with the crop. This situation has resulted in the non-certification of power threshers. It would be desirable if the technologists should suggest those parameters for incorporation in the standard for quality certification.

Active Participation

Standardization, as stated earlier, is a process in which attempt is made to take the advice and help of all people engaged in the profession. Some people act as members of the committees. Some are invited to take part in the deliberation and others are asked to scrutinize and send comments. The drafts are generally issued for three months and it is expected that concerned people will act on the draft and problem faced would be communicated. Response in this has also been seen that the people who are party to a decision on a standard when they are approached for implementation raise technical problems delaving the process of quality certification. It is, therefore, hoped that people in the profession would feel a sense of involvement from the initial stage of standardization so that practical standards could be evolved.

Will for Implementation and Certification

Implementation of standars is required to be done by all engaged in the profession. A purchaser can implement this by asking the products as per Indian Standard or certified items, manufacturer can follow the standard in the process of manufacture and also by covering under quality certification. Testing stations and laboratories should equip themselves to carry out the tests as per Indian Standard. In teaching and developmental work, use of standards should be made. The trade should use the standards in their inter- and intracountry negotiations. Only the implementation and certification can bring out the deficiencies in standard for rectification. In the past even directives issued by he Ministry of Agriculture, Directorate General of Technical Development and Development Commissioner (Small Scale Industires) at centre level and various Directors of Agriculture at State level have not helped much in mass coverage of implements under quality certification. Manufacturers, on the one hand, say that there is no sufficient market for quality items (since substandard items are cheaper in the market) and, on the other hand, purchasers say that quality certified items are not available. It may be true that at some moments a purchaser may not get a certified product but he can evaluate the product on the basis of the standard. Once he brings standard into the picture in subsequent purchases he would get a certified product. For quick coverage under quality certification a purchaser may give some price preference to certified items over non-certified items. Quoting again John Ruskin, 'there must be the will to produce a superior thing'.

Dovetailing of Standards in Education

Considerable progress has been made in the expansion of agricultural engineering education in the country. Introduction of standardization as a subject in the syllabus would help in knowing the advantages and principles of standardization by young engineers coming from the universities so that they can contribute to this field with realistic approach. Indian Standards could be utilized in assigning the problems for undergradute and post-graduate students for in-depth study of a product vis-a-vis standard. It was heartening to note that at the IIT, Kharagpur Indian Standard on paddy thresher has been assigned to a post-graduate student for detailed study. It is suggested that other universities should also take steps in this direction.

Strengthening of Standardization at Various Levels

Standardization is a four-tier process which has to be carried out at company level, association level, national and international level. When applied to agricultural machinery, standardization at association level is not existing at all and at company level, too, no work has been done except in a few firms. It is, therefore, necessary to instill standard consciousness at all levels. The Indian Society of Agricultural Engineers can help in the preparation of standards at association level on the lines of work being done by their counterpart in U.S.A. This would eventually provide a sound basis for standardization at national level. Companies can utilize the facilities from the ISI for the development of their company standards programme.

Formation of Association

In the field of farm machinery there is no organized and effective association of consumers and producers which can put forth collectively their views and activate the developmental programme. Besides, the supply of the raw material could also be probed through such associations which could solve the present problem of non-availability of steel to small manufacturers at economical rates.

Conclusion

The farm machinery and power industry is set for large scale expansion in the near future to meet the domestic demand as well as to fulfil the commitments for export. In consonance with this gorwth, there is a reasonable demand for the formulation of Indian Standards. Though standardization activity was started and geard to meet this demand a deeper understanding of the problem and "spade work" is necessary, before the country reaps the full benefits from national standardization which has to be a joint venture of the industry, research bodies, testing units and the ISI.

With the tremendous standardization efforts in this industry already put in and various technical issue threshed out with the active participation of the experts, the goal of achieving the breakthrough in quality certification of farm machinery should be within reach. What perhaps needs to be underscored is the willingness on the part of the manufacturer to produce quality items and the purchasers to give preferential treatment to certified products. ■■

Effect of Field Size on Machine Field Efficiency and Ploughing Costs

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Introduction

Agricultural production in Egypt has to increase at a much higher rate than the current rate in order to feed an alarming increase in population living on a limited cultivated area. Appropriate farm mechanization, jointly with improved agricultural techniques which help increase crop yield, has proved to benefit agriculture substantially. However, the actual physical conformation of land holdings in Egypt presents a chronic problem toward the expansion of mechanization.

According to the 1969 census, more than 95% of the land owners in Egypt possess less than 5 "feddans"* (about 2 ha). Sixteen percent of the cultivated are belongs to small farmers with less than one feddan each. (Table 1)

This situation is accentuated by further fragmentation of land ownership as the majority of small holdings are sub-divided into a number of dispersed parcels of lands.

Table 1. Land Distribution in Egypt, 1969 (For 5 feddan and less)

Size of Holdings (in Feddan)	Total Cultivated Land Area (1,000 Feddan)	Percent of Total	Percent Ownership
Less than one feddan	911.4	16.6	70.1
" " 2 "	1,478.4	26.9	82.9
" " 3 "	1,939.8	35.3	89.5
" " 4 "	2,329.0	42.4	93.1
" " 5 "	2,680.3	48.8	95.5

These fragmented holdings reduce the field capacity and, consequently, increase the cost of mechanized operations, in addition to the excessive time lost in moving the machine from one parcel to begin work in another parcel, even if not far from it.

Field dimensions have a great impact on field capacity, affecting the number of turns at corners of the field, thus representing a loss of time that is often of considerable importance, especially in small fields.

This paper reports on the result of investigation of the field capacity and operating cost in relation to field shape and area using two types of tractors: the standard 4 wheel type, 65 HP tractor and the small walking type tractor of 18 HP.

Field Efficiency

McKibben (1930) stated that time lost in turning, idle travel across the end and field adjustment of the machine usually tends to be proportional to the effective operating time. The relative importance of interruption proportional to the

* One "feddan" = 0.42 ha

area may be determined from the following equation, which is based on the definition of field efficiency:

$$E_f = \frac{T_o}{T_e + T_t + T_i}$$

Where:

T_o = theoretical field operating time per feddan.

T_e = Effective field operating time per feddan

$= T_o \times \frac{100}{K}$

K = Percentage of implement width actually utilized

T_t = Time lost in turning/feddan

T_i = Time lost per feddan due to interruptions proportional to area

Methods and Equipment Used

Two main experiments were carried out through two successive seasons, namely; 76/77 and 77/78 in Sharkia Egypt.

The First Experiment

The experimental field covered an area of 66 feddans divided into 4 groups of plots according to the shape of plots and directions of ploughing,

a. Rectangular plots, with length twice the width, ploughed cross-wise:
b. Square plots.
c. Rectangular plots, with length twice the width, ploughed length-wise, and
d. Irregular plots, ploughed length-wise.

Each group of plots was calssified into eight different sizes as follows:

1/4, 1/2, 3/4, 1, 2, 3, 4, 5, feddans.

Gathering method of ploughing was performed at the optimum soil moisture content and a constant average depth of 20cm. All tests were carried out on a clay soil on trifolium stubble. A 65-HP, four-wheel, standard tractor equipped with 7 rigid tines chisel plough was used in the first set of experiments. This type of tractor and plough is actually used for mechanized ploughing in Egypt.

Time of Operation

Total time of ploughing each of the areas included the effective time actually consumed in ploughing lost time consumed in turning and minor field repairs and maintenance. By effective time is meant the time actually consumed in performing the actual ploughing operation.

The Second Experiment

This experiment was carried out in 1.75 feddan-sized farms to determine the field efficiency of the motor cultivator (2-wheel walking tractor) equipped with a rotary tiller was powered by an 18-HP diesel engine and operated at a forward speed of 2.7 m/hr.

Rectangular shaped plots were for ploughing using the continuous method of ploughing.

The experimental area was divided into small plots of 1/4 feddan each. The same type of land was used as in the first set of experiments but ploughing depth was limited to 10 cm to conform with the power limit of the moto-cultivator.

Results

Data obtained from the 1st experiment, using the 65 HP-tractor equipped with mounted type chisel plough are indicated in the **Tables 2, 3, 4, 5, 6, 7 and 8.**

Table 2. Field Efficiency as Affected by Land Shape and Size

L/W Ratio	Field efficiency (Percent)							
	1/4F.	1/2F.	3/4F.	1F.	2F.	3F.	4F.	5F.
1/2	40.9	53.6	55.8	62.4	64.1	68.1	70.7	71.3
1	52.5	55.2	62.0	65.8	68.7	76.0	71.7	73.1
2	55.5	58.0	64.5	69.2	72.0	73.7	76.2	77.3
Irregular	63.7	60.0	68.4	60.2	71.4	66.2	67.8	73.8

Table 3. Percent Ratio Between Turning Time and Total Time as Affected by Land Shape and Size

L/W Ratio	(Turning Time/Total Time) (Percent)							
	1.4F.	1/2F.	3/4F.	1F.	2F.	3F.	4F.	5F.
1/2	45.5	38.3	34.6	31.1	22.9	18.1	13.8	14.4
1	39.4	26.9	24.8	23.3	17.4	12.8	12.0	11.3
2	28.6	24.1	17.4	16.2	11.4	9.7	8.0	7.2
Irregular	17.5	20.5	16.0	15.9	9.0	9.8	6.3	5.6

Table 4. Effect of Plot Shape and Size on Time Consumed in Field Minor Repairs and Maintenance

Field Area (feddan)	Repair and Maintenance Time Over Total Time (Percent)				Average Value (%)
	L/W =1/2	L/W =1	L/W =2	L/W = Irregular	
1/4	9.3	8.0	8.0	7.0	8.1
1/2	9.0	4.1	4.2	5.3	5.7
3/4	4.4	2.8	2.9	6.6	4.2
1	4.6	4.6	4.0	1.4	3.7
2	2.2	2.9	2.3	2.7	2.5
3	1.9	2.5	1.8	3.2	2.4
4	3.2	2.4	2.0	2.3	2.5
5	1.9	1.8	2.1	2.4	2.1

Table 5. Total Time Consumed in Ploughing One Square Meter (one pass) with Reference to L/W Ratio

Field Area (feddan)	Time in Seconds to Plough one Square Meter				Average (sec.)	Time/fed. (Hr) (one pass)
	L/W =1/2	L/W =1	L/W =2	L/W Irregular		
1/4	1.61	1.22	1.18	1.05	1.27	1.48
1/2	1.20	1.29	1.06	1.03	1.15	1.34
3/4	1.27	0.99	1.08	0.93	1.07	1.25
1	1.01	0.98	0.95	1.01	0.99	1.15
2	0.98	0.95	0.90	0.83	0.92	1.07
3	0.97	0.91	0.81	0.94	0.90	1.05
4	0.77	0.90	0.71	0.91	0.82	0.96
5	0.88	0.85	0.69	0.82	0.81	0.94

Table 6. Relation Between Time Consumed, Field Efficiency and Plot Area

Area (Feddan)	Time per minute		Field Efficiency (%)
	Theoretical* (Estimated)	Actual	
1/4	38.3	66.0	58.0
1/2	76.5	127.6	60.0
3/4	114.8	193.6	59.3
1	153.0	250.4	61.1
1 1/4	191.3	313.8	61.0
1 1/2	229.5	386.0	59.5
1 3/4	267.8	446.0	60.0

Average field efficiency: 59.8%

*At operated speed of 45 m/min or 2.7 km/hr, theoretical width of tiller, 62 cm; and theoretical field capacity 27.45 m^2/min.

Table 7. Relation Between L/W Ratio and Plot Area at Average Efficiency (59.8%)

Area (Feddan)	(Length (L) (m)	Width (W) (m)	L/W	Field Efficiency (%)
1/4	76	14.0	5.4	58.0
1/2	76	28.0	2.7	60.0
3/4	76	41.0	1.9	59.3
1	76	55.0	1.4	61.1
1 1/4	76	69.0	1.1	61.0
1 1/2	76	83.0	0.9	59.5
1 3/4	76	87.0	0.8	60.0

Table 8. Comparison of Operation Cost, 65-HP Tractor and 18-HP Motor Cultivator

Cost Item	65-HP Tractor		18-HP Motor Cultivator
	Lower Limit	Upper Limit	
Initial cost (LE)	4,500	6,000	1,500
Lief expectancy (hrs)	8,000 hrs	10,000 hrs	5,000 hrs
Life expectancy (years)	8 years	10 years	10 years
At a rate of fixed cost/hr	1,000 hrs/year	1,000 hrs/year	500 hrs/year
Depreciation	0.562	0.600	0.300
Interest	0.202	0.270	0.135
Variable cost/hr			
Fuel	0.175	0.175	0.023
Oil & lub.	0.085	0.085	0.021
Main. & repair	0.506	0.540	0.300
Wage	0.150	0.150	0.250
Total/hr.	1.680	1.820	1.029

Cost of operating of plough with the tractor:

Initial cost: LE. 250
Depreciation/year: 25
Interest: 11.25
Repair and spare parts: 22.50

LE./year 58.75

Average working hrs/year : 250 hr.

Operating cost/hr = 0.235 L.E/hr

(Lower limit) Total cost of ploughing one pass/hr =

1.680 + 0.235 = 1.915 L.E/hr

(Upper limit) Total cost of ploughing one pass/hr =

1.820 + 0.235 = 2.055 L.E/hr

Average cost = 1.985 L.E/hr.

≅ 2.000 L.E/hr

Discussions

Field Efficiency Using the 65-HP Tractor

Beside the basic factors affecting the field efficiency of a machine such as field topography, soil type, moisture content, tractor type, effective width of the machine, etc. two other factors predominent in Egypt must be taken into consideration. These factors are: the size of field and length to width ratio. The results obtained show a remarkable drop in the field efficiency - with a consequent sharp rise in the cost of operation - as both the field area and its $\frac{L}{W}$ ratio decreased **(Table 2)**.

Field efficiency dropped to 40.9% for the 1/4 feddan area withh $\frac{L}{W}$ = 1/2 and reached 77.3% for the 5 feddan area with $\frac{L}{W}$=2. The major reason for the drop was the time consumed in turning at the ends of the field.

With a field area of 1/4 feddan and $\frac{L}{W}$ = 1/2, the turning time represented 45.5% of the total ploughing time. When the area rose to 5 feddans, he turning time was reduced to only 14.4% of the total time with the same $\frac{L}{W}$ ratio **(Table 3)**. Time consumed in field repair and maintenance **(Table 4)**, as related to total ploughing time, was also greatly affected by the field area. For small fields of 1/4 feddan it represented an average of 8.1% of the total time, as compared to only 2.1% for the 5 feddan areas. **Table 5)** shows the total time consumed in ploughing, calculated on the basis of unit area of one square meter, for different fields size and length to width ratios.

By calculating time/feddan for different field sizes and taking an average for different $\frac{L}{W}$ ratios, the figures obtained of time/feddan will serve as an indicator ranging from 1.48 hrs/feddan for plots of 1/4 feddan to 0.945 hrs/feddan for plots of 5 feddans. This means that one feddan if divided into quarters will consume 1.56 times (1.48/0.945) as much as one feddan when ploughed within a contiguous area of 5 feddans, not taking into account the travel time lost between consecutive fields.

The above results reveal the great reduction in mechanization cost if land consolidation were adopted to replace the actual state of land fragmentation.

Field Efficiency Using 18-HP Motor Cultivator

From the obtained results, the field efficiency and field capacity were hardly affected by either field area or its length to width ratio.

Field efficiency ranged from 58% to 61.1% with an average of 59.8% for plots ranging from 1/4 feddan to 1 3/4 feddans.

Travel Time Between Fields

Not only does the mechanized ploughing per feddan soar high for the 1/4 feddan fields when compared with the cost per feddan for the 5 feddans areas, but also due to the time consumed by travelling from one field to the next. This difference in cost/unit area becomes greatly magnified the smaller the fields become. (See Table 9 for tractors and Table 10 for motor cultivators).

If 10 minutes were taken as average travel time, the cost of

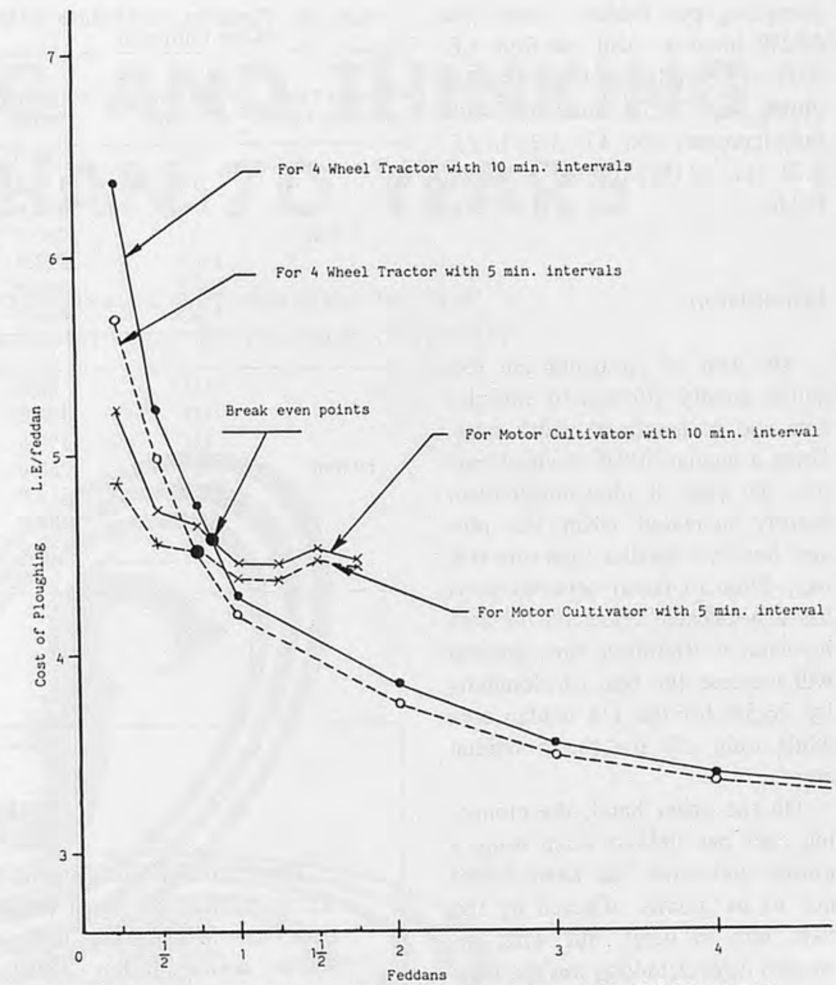

Fig. 1 Cost comparison of ploughing rice feddan using a 4-wheel 65 hp tractor and a 2-wheel 18 hp. tractor for different farm sizes

Table 9. Ploughing Cost/Feddan for Different Field Sizes Using a 65-HP Tractor
a) allowing 5 min. travel time between fields.
b) allowing 10 min. travel time between fields

Field size (feddan)	Total Ploughing Time One pass (min)	Total Time Required to Plough			Cost per Feddan (LE)		
		Two passes (min) (a)	Two passes 5 min interval (b)	Two passes 10 min interval (c)	Zero travel (a)	5 min. travel (b)	10 min. travel (c)
1/4	21.9	37.66	42.66 (13.3%)	47.66 (26.5%)	5.02	5.69	6.35
1/2	40.2	69.15	74.15 (7.2%)	79.15 (14.5%)	4.61	4.94	5.25
3/4	56.2	96.66	101.66 (5.2%)	106.66 (10.3%)	4.29	4.52	4.74
1	69.2	119.02	124.02 (4.2%)	129.02 (8.4%)	3.97	4.20	4.30
2	128.0	220.16	225.16 (2.3%)	230.16 (4.5%)	3.67	3.75	3.84
3	180.2	309.94	314.94 (1.5%)	319.94 (3.3%)	3.44	3.50	3.55
4	230.6	396.6	401.60 (1.3%)	406.6 (2.3%)	3.30	3.35	3.39
5	283.3	487.28	492.28 (1.0%)	497.28 (2.0%)	3.25	3.28	3.31

Figures in parenthesis indicate the time increase in percent as compared to time needed to plough the field without allowing travel time between fields.

ploughing per feddan - using the 65-HP tractors - will rise from LE. 5.02 to LE. 6.35 for the 1/4 feddan plots, i.e., 26.5% increase) while only increases from LE. 3.25 to LE. 3.31 (i.e., 2.0%) for the 5 feddan fields.

Conclusion

The cost of ploughing per feddan is greatly affected by the plot area and its length to width ratio. Using a regular 60-HP 4-wheel tractor, the cost of ploughing/feddan sharply increased when the plot area becomes smaller than one feddan. Time to travel between plots has a noticeable effect on the cost increase. A 10-minute time interval will increase the cost of ploughing by 26.5% for the 1/4 feddan area while only 2% for the 5 feddan areas.

On the other hand, the ploughing cost per feddan when using a motor cultivator has been found not to be greatly affected by the field size in itself, but what increased its cost/feddan was the time travel between plots, especially when equal to or greater than 10 minutes for areas less than half a feddan.

Finally, the results reveal that for areas less than 3/4 feddans, the motor cultivators might be more economical than the regular 65-HP tractors if the type of tillage offered by the rotary plough at a depth not exceeding 10 cm is acceptable to the farmers. Otherwise the regular chisel ploughing with 2 passes, executed by the 4 wheel 65-HP tractor is clearly more economical especially when ploughed plots exceeds the size of one feddan. ■■

Table 10. Ploughing Cost/Feddan for Different Field Sizes Using a 18-HP Motor Cultivator

Travel Time Between Fields	Field Area (Feddan)	Total Time (min)	Total Ploughing Time + 5 min (min)	Ploughing Time per Feddan (Hour)	Cost per Feddan LE.
5 min	1/4	66.0	71.0	4.73	4.87
	1/2	127.5	132.5	4.43	4.56
	3/4	193.6	198.6	4.41	4.54
	1	250.4	255.4	4.25	4.39
	1 1/4	313.8	318.8	4.25	4.38
	1 1/2	386.0	391.0	4.34	4.47
	1 3/4	446.0	451.0	4.30	4.43
			Average	4.39 hrs.	LE. 4.52
10 min	1/4	66.0	76.0	5.07	5.22
	1/2	127.5	137.5	4.58	4.72
	3/4	193.6	203.6	4.52	4.65
	1	250.4	260.4	4.34	4.47
	1 1/4	313.8	323.8	4.32	4.45
	1 1/2	386.0	396.0	4.40	4.53
	1 3/4	446.0	456.0	4.34	4.47
			Average	4.51 hrs.	LE. 4.64

ERRATA

The Editorial Management regrets the inadvertaence in the article "Effect of Speed on Specific Draft of Moldboard and Disc Plow in Bangkok Clay", AMA, Vol. X, No. 3, pp. 33–38 whose senior author should be Mr. Surendra Singh of Jordbrugsteknisk Institut, Rolighedsej 23, DK, 1958, Copenhagen, Denmark. The junior authors are Dr. Gajendra Singh and Professor T. Tougaard Pedersen, in that order.

In addition, the following errata on the same AMA issue are made:

p.9: Editorial title should read *Wanted* instead of Watned.

p.19: Fuji in title of article should read *Fiji*.

p.20: Center col., 3rd line, photoshynthetic should read *photosynthetic*.

p.21: 1st col., 16th and 17th lines should read: ... (classified by crops, subsistence and purchased foods and by adult units)

p.21: Tables 1 and 2, last col., Symbol below Food costs should read *$* instead of g.

p.28: 1st col., 11th line should read ... dominant *system of agriculture* ...

p.29: 2nd col., 4th line should read *higher* instead of high.

p.29: 2nd col., 12th line and No. 7, p. 32 should read *Borgstrum*.

p.38: 1st col., equation (2) should read $D = 95.0 + 52.9S$ (2)

p.38: 1st col., the paragraph below equation (2) should read "The coefficient of correlation was *70.6* percent. The average percent errors for this curve on the positive and nagative sides were *2.9* and *2.8* percent of predicted value"


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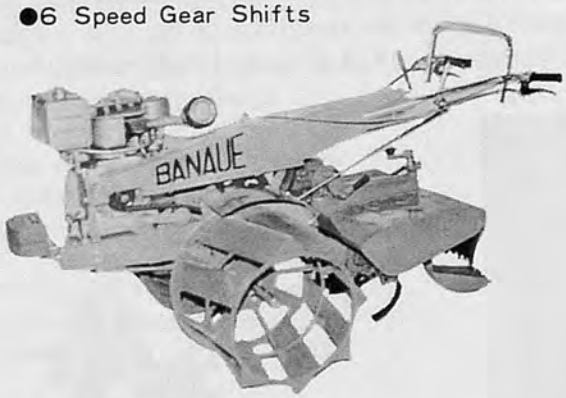
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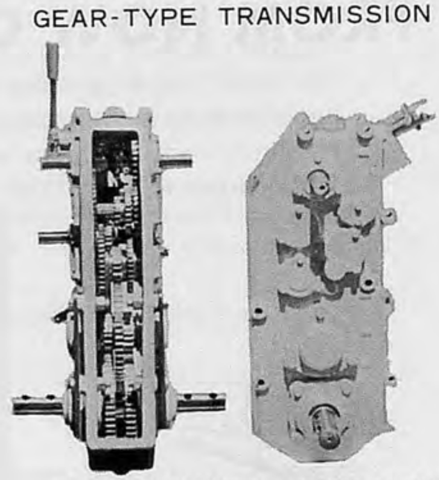

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Chisel Plowing vs. Moldboard Plowing

by

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Abstract

The question, whether chisel plowing is better for the American Mid-Western farmer than moldboard plowing, has been debated. Data presented here is mostly for the U.S., but the principles also apply to Asian conditions. For heavier soils, the MB will do a better job whereas chisel plow would be more appropriate for lighter soils. Also, this report is not suitable for paddy rice fields, e.g., in Japan.

Introduction

Chisel plows are gaining favour with many farmers as an alternative to conventional moldboard (MB) plows. They require less power per foot of width and can cover 60 percent more acreage daily when operated at comfortable speeds (The Ohio Farmer, Sept. 1977). MB plow and chisel plow are tillage tools used to manipulate soil from a known condition into a different desired condition. Both are primary tillage tools. Relative performances of both are discussed under 15 headings.

Method of Working and Definition

The MB plow is one of the oldest of all agricultural implements in the US and is generally considered to be most important implement. Thomas Jefferson (1788) applied mathematics to MB plow and the first patent was granted in 1797 for cast iron moldboard plow. Its use in India dates back to the later part of the 18th century when the British imported these plows to improve Indian agriculture. MB plow pulverizes, aerates and loosens the soil. Usually some trash is buried and mixed with soil. By completely or partially inverting the soil, the new and unused plant nutrients are provided near the surface for the new plant seedlings.

The first chisel cultivator came into use in 1860 in the US. Heavy-duty, deep-tillage chisel plow was used to penetrate subsoil of irrigated land in 1895. Chisel plow is a tool with a rigid curved or straight shank with relatively narrow shovel points. The soil is stirred more or less in place. Soil is broken but not inverted and pulverized to the extent that MB plow crushes the soil. Chiselling operation does not throw enough soil to cover trash thoroughly (stubble-mulch). This plow is useful in breaking hardpan/plough sole.

Cost of Plowing

Custom rates for 1962 from "Farm Machinery and Equipment" (H.P.Smith) are given in **Table 1.** Bulletin No. L-74 Ohio State Univ., Dept. of Economics and Rural Sociology, Co-operative extension service gives custom rates for 1974 for NE, NW, SW, SE. The data for midwest United States (Hunt D., 1977) show the cost for moldboard plowing and chisel plowing as \$7.50/acre and \$6.00/acre, respec-

Table 1. Custom rates in the US, \$/acre

Job	North Central	North East	South	Mountain	Pacific
Plowing-MB					
Spring	3.50	4.60	3.75	5.00	4.50
Fall	3.75	5.00	3.75	4.75	4.75
Sod	4.25	5.25	4.25	6.00	6.00
Chiselling	2.25	-	4.00	3.35	-

(Smith).
(Rates include labour and fuel charges).

tively.

These data show decreased cost for chiselling compared with moldboard plowing. These are, of course, custom operation charges, but they do reflect actual costs involved.

Seedling Attachment on Plows

Seedling attachment can be hitched to the chisel plow as well as the MB plow.

Depth of Plowing

The depth of chisel plowing may be as shallow as desired and as deep as 18 inches (Smith, H.P). Cooper in 'Compaction of Ag. Soils' defines chiselling as the operation less than 16-inch deep and subsoiling as the operation deeper than 16-inch. Payne defined chisels/tines as tools with a depth/width ratios greater than 1:1.

Randolph and Reed observed that the minimum draft for a 14-inch MB bottom was at depths of 5 to 7-inches (Bainer, et. al., page 145). Gulvin, in his book, Mechanics for Power Farming recommends an average depth of 6-inches and a draft force of 90 lbs to pull a 14-inch bottom for each inch of depth.

Size of Plows

Mounted MB plows have 2 to 5, 12, or 16 inches bottoms. Semi-mounted and pull type MB plows have 4 to 8, 14 or 16 inches bottoms.

For the chisel plows, furrows may be as close as 12 inches or as wide apart as 2–3 feet. Some types of chisel plows are available in sizes ranging from 5 to 45 foot widths. Chisel plows up to 20 feet wide may be 3-point mounted or trailing type. Above that, they are trailing type. The 3-point mounted models have 2 or 3 bars or ranks, while trailing types have 3 or more ranks.

Representative farm machinery prices for both types of plows (Hunt D., 1977) are given in **Table 2.**

Table 2. Plow costs

Chisel Plow :	
Pull	100– 160 $/foot
Rear-mounted	105 $/foot
Moldboard Plow :	
One-way	
Mounted	275– 400 $/bottom
Semimounted	400– 600 $/bottom
Pull	500 $/bottom
Two-way	800–1100 $/bottom

(Hunt, 1977).

Construction of Plows

The plow bottom of a MB plow is 3-sided wedge with the landside and the horizontal plane of share's cutting edge as flat sides and the top of the share and the MB together acting as a curved side. Primary functions include cutting the furrow slice, shattering the soil and inverting the furrow slice to cover the trash. Clearances behind the cutting edge are called horizontal and vertical suctions. From a functional standpoint common types include general purpose bottoms, stubble bottoms, deep tillage bottoms, sod bottoms, blackland bottoms and slat moldboard. MB are generally made from soft-center steel. Shares are made from C-1095 solid steel and hardened by heat treatment.

Replaceable shins are sometimes made from chilled cast iron. Rolling coulters are used with these to help cut the furrow slice and cut through trash that might otherwise collect on the shin or beam and cause clogging. Normal operating speed range is 3–6 mph at field efficiency of 70–90% (ASAE Year Book, 1977).

Chisel plows can have reversible tines. Edges are sharpened to help in cutting action. These tines are not as wide as moldboards. Maximum width may be up to 3–4 inch. The angle made by the tine with the horizontal is called a lift angle. Lift angle and slope of standard affect the draft. Normal operating speed may range from 4–6½ mph (ASAE Year Book, 1977) at 70–90% efficiency.

When operating at speeds comparable to those used in MB plowing, one can plow about 60% more acreage per day than one can with a moldboard.

Effect of Plow Shapes on Draft and Vertical Soil Forces

The approach angle (lift angle) in a chisel plow greatly affects both the normal pressure on the tool and amount of soil disturbed by the tool. Figure 183 (Ag. Hand book No. 316, page 258) shows the average normal pressure on the sliding surface of a straight chisel operated 6 inch deep for all angles of inclination. A 90° angle of inclination represents the tool operated in a vertical position. The decrease in average normal pressure with decreasing angle is also associated with reduced total draft. Figure 184 (Ag. Handbook No. 316, page 258) explains how an approach angle affects the shape and volume of soil disturbed. Payne (Ag. Handbook No. 316 page 257) reported that the draft of a straight chisel 4-inch wide ranged from 425 lbs at an approach angle of 160° to 90 lbs at 20°. Figure 218 (Ag. Handbook No. 316, page 315) explains the effect of lift angle, moisture content on the pressure on the tool surface (negative correlation). It shows that any factor that increases the draft of the tool also increases the pressure on the surface of the tool.

Tanner found that when a lift angle was greater than 50° a stationary cone of compacted soil remained at the tip, increasing in size as the lift angle was increased. Although 20° lift angle and 20° slope of the standard would be good from the standpoint of low draft and large downward V, such a design would not be feasible. A practical compromise is to have a curved standard with slope increasing from 15 to 20° at tool point to 90° or less at ground surface.

The shape of the MB has a definite influence on draft, although the relative effects are influenced by soil type and conditions, speed, and perhaps other factors. Reed (Bainer et. al., page 146) found distinct differences in specific draft for different types of plow bottoms of MB. In general, shapes that give the best trash coverage or the greatest degree of pulverization tend to have the highest drafts, although the converse may not be true. Three different shapes of 14-inch plow bottom had drafts of 266, 290, 317 lbs in clay soil. Flat shares had 3 to 10% more draft than the modified-curve share. Worn shares may have greater draft than the new ones. Draft of average plow bottom constitutes 18% pulling, 48% cutting furrow slices and 34% turning over the slice. Disc-joint coulter and coulter-jointer on a MB plow had a draft of 203 lbs and 369 lbs at 3.00 mph in Norfolk Sand at 5½% moisture, operating at 3½ inch deep (Ag. Handbook No. 316, page 289). Draft was increased with use of light soil as compared to heavy soil. Effect of wear on the angle of sharpness and specific draft resistrance is given in **Table 3**. (Ag. Handbook 316, page 248). Effect of wear on specific plow resistance and fuel consumption is also shown in Figure 172 (Ag. Handbook No. 316, page 247) and this shows positive correlation.

Table 3. Effect of wear on the angle of sharpness and specific draft resistance

Soil type	Area plowed (acres)	Angle of sharpness of plow share (°)	Specific draft resistance (Kg/Sq.cm.)	Increase in draft resistance (%)
Loam	0	15	0.50	0
	4.9	30	0.59	18
	12.0	36	0.63	26
	17.0	42	0.66	32
Sand	0	15	0.31	0
	6	28	0.35	13
	14	32	0.37	19
	30	40	0.40	29

(Gill, et.al., page 248).

Table 4. Effect of speed and soil type on MB draft

Speed, mph	1	2	3	4	1	2	4
Draft, %	100	100–114	128	142	100	117	126
	Clay loam soil				Black loam soil		

(Davidson, et.al.).

Table 5. Draft versus speed relations.

Source	Relation	Remarks	
Gill, et.al. page 264	$D = k(S-3)1.5$	k = Coefficient from 5 to 15 depending on tool	
	$D = D_0 S$	D_0 = Base draft for a given speed & soil condition	
	$D = D_0 + cS^2$	c = Constant 0.95 for helicoidal-shaped plows	
		= 3.67 for digged-shaped plows	
Hunt, 1977	$D = 7(10.24)+0.049(.185)S^2$	Silty clay(S.Tex.),	D = Unit draft, psi
	$= 6(8.77\ )+0.053(.200)S^2$	Decatur clay loam	S = Speed in mph
	$= 4.8(7\ )+0.024(.09\ )S^2$	Silty clay (N.ILL.)	
	$= 3(4.5\ )+0.021(.08\ )S^2$	Davidson loam	
	$= 3(4.4\ )+0.056(.21\ )S^2$	Sandy silt	
	$= 2.8(4\ )+0.013(.05\ )S^2$	Sandy loam	
	$= 2(3\ )+0.013(.05\ )S^2$	Sand	

Effect of Speed upon Draft

In case of MB plows, increasing the forward speed from 3 mph to 6 mph increases the draft by an average of 50% for conventional plows in a variety of soils. $D_s = D_o + kS^2$ where D_s = draft at speed S, D_o = Static component of draft, K = constant governing the design of implement and type of soil conditions. Mckibben & Reed (Bainer, et. al., page 147) represented their data by the relation $D_s/D_3 = 0.83 + 0.0189\ S^2$ where D_3 = draft at 3 mph, D_s = draft at speed S. This equation is for average MB shapes commonly used prior to 1949. They indicated that average increase in draft between 2 and 4 mph was only 25%, the increase between 3 & 6 mph was 50%. Studies made in Ohio by Ashley, Reed, Gloves show that with 2-bottoms the average increase in draft due to increased speed was 1.17 psi of furrow slice for each mile per hour increase in speed. Data of Davidson et. al., is given in **Table 4**. Draft vs speed relations (Ag. Handbook No. 316, page 264) are summarized in **Table 5**. A term called unit draft is often used. It is independent of both plow width and furrow depth. Unit draft equations for specific soils and for plow equipped with high speed MB, coulters and landsides (Hunt, D 1977) are given in **Table 5**. These equations are multiplied by 1.07 for an added jointer or coverboard. An increase in soil moisture content of 1% can decrease draft by 10%. An increase in apparent specific gravity of 6.2 lbs/ft^3 can increase unit draft by

10%.

Most of the data on effects of speed on chisel plows draft is for flat-plate tines at low speeds and might not be meaningful in relation to field operation. Payne found 11 to 16% increase in draft between 3 and 6 mph for 3 soil types. Reed observed 4–13% increase in draft between 3 to 6 mph for loamy soil. Mckibben & Reed suggested following relation: $D_s/D_3 = 0.944 + 0.0062\ S^2$. The draft increase between 3 and 6 mph was 16%. Total surface area, lift angle, depth and soil condition undoubtedly influence the magnitude of speed effect. In some cases a linear relation between draft and speed can be assumed over a limited range of speeds.

Frequency of Operations

Under adverse soil conditions, or when it is desirable that soil should not be inverted, chisel plows are sometimes employed for primary tillage operation in place of MB. Because the chisel plows do not pulverize the soil as much as MB, therefore, a greater number of subsequent operations may be needed to obtain a good seedbed after chiselling.

Effect of Depth of Cut on Draft

Specific draft of an MB plow generally decreases as the depth is increased to some optimum depth/width ratio and then increases as the depth is increased further. The increase in specific draft beyond optimum depth is probably due, in part, to choking of thick furrow slice in the curvature of MB. Deep tillage plow bottoms have higher specific draft than standard bottoms.

The specific draft of a 14 inch MB plow in several soil conditions is shown in Figure 186 (Ag. Handbook No. 316). The data indicate that depth of operation can be increased up to 5 inches in most soil conditions without any appreciable increase in specific draft.

In case of chisel plowing, results obtained are not consistent with regard to effect of depth on draft. It is likely that the effect of depth is influenced by the tool shape, orientation, soil type and soil condition. The results indicate a general tendency for a moderate increase in specific draft as depth is increased in firm soil. The effect of depth of operation on draft force (Ag. Handbook No. 316, page 261) is given in **Table 6**.

Table 6. Effect of depth of operation on draft force

Depth of operation (cm)	Draft force (Kg)	Draft per unit width of disturbed soil (Kg/cm)
8.3	507	5.1
18.3	1,259	13.3
28.3	2,159	21.3
33.6	3,264	30.4
35.2	3,338	33.2
40.6	4,334	39.6
43.8	5,200	42.1

(Gill, et.al., p:261).

Effect of Width of Cut on Draft

Getzhoff (Ag. Handbook No. 316) found with 26 cm MB plows, the specific draft increased as the width of cut was reduced below 26 cm. Gill and McCreery found that specific drafts for 2-inch, 1-inch cuts were 40% and 14%, respectively, greater than the average for 4-inch, 6-inch and 8-inch width of cut. Randolph & Reed found the values of specific draft as 2.0, 2.1, 2.1, 2.1, 2.2 psi for 8, 10, 12, 14, 16-inch width of cut for 12-inch MB in a sandy soil. Since the shape of a MB plow is complex, varying its width of cut changes the path soil takes as it moves over the surface of the plow. Thus the shape of a tool is also changed as width of cut is varied. Limited data show only a slight change in specific draft. Gill and McCreery (page 262, Ag. Handbook No. 316) used different shapes of MB to vary width of cut.

For chisel plows, increased width of cut might result in decreased specific draft. Table 28 (page 263, Ag. Handbook 316) shows that specific draft generally tended to decrease as the size of cut was increased. Since lower specific draft indicates a lower force/unit area of Xn, the increase in width of cut is advantageous. On the other hand, for a high degree of pulverization, smaller width of cut is advantageous.

Effect of Soil Conditions on Draft

The effect of moisture on draft force is that decreasing soil moisture form 20.1% to 15.9% would increase draft of MB plow from 689 1bs to 806 1bs in Houston clay soil. Data from a textbook by Gulvin is given in **Table 7**. Values of specific draft range from 2 to 3 psi for sandy soils up to 15 to 20 psi for heavy gumbo soils. Sandy or silt loams may have specific drafts from 3–7 psi where 6–12 psi would be typical for clay loams and heavy clay soils. A dry soil requires excessive power and accelerates wear of cutting edge. In USDA soil bin

Table 7. Effect of soil conditions on unit draft

Draft (psi)	3–4	4–6	5–6	6–7	6–7	7–8	9–10	10–11	3
Soil	Sandy loam		Silt loam		Clay loam		Heavy clay		Sandy
	moist	dry	moist	dry	moist	dry	dry	sod	

(Gulvin)

tests, an increase of moisture from 9.1 to 11.7% reduced specific draft in fine sandy loam soil by 15 to 35% when apparent specific gravity. changed from 1.68 to 1.83 (Principles of Farm Machinery). A textbook by Hunt suggests adjustments in unit draft due to changes in moisture and apparent specific gravity.

In the case of chisel plows, power requirements are much less at the higher moisture content (compaction of Ag. Soils, page, 341).

Method of Hitching

Clyde recommends that for MB plows the preliminary adjustment of the hitch height on the plow frame be such that P_v passes through a point slightly below the ground surface and directly above the average location of all share points. Draft can be affected by adjusting the rear wheel base, shifting the pulling point on the drawbar. Details are discussed in "Principles of Farm Machinery" for various types of plows.

Chisel plows require single axle type of hitching with rigid pull members. It is balanced in the horizontal plane and hence needs to be adjusted in the vertical plane. When a single-axle type implement receives vertical support only through its wheels, the location of Q_v is fixed. The line of Q_v must pass slightly behind the axle centerline (Figure 8.3, in Bainer, et. al., page 173) in order to supply torque to overcome wheel-bearing friction and cause rotation of the wheels. The only possible hitch adjustment is changing the height of drawbar at hitch point.

Clod Size and Pulverization Action

Table 8. Clod breakup data

Clod mean wt. dia. (")	Specific draft (PSI)	Size of cut (")	Energy applied to tool by soil (ft-Ld/Cuft)	Equivalent energy to cause soil breakup (ft-1d/ft³)	Efficiency of tool
1.47	27.7	1	2256	1790	0.79
3.55	16.0	2	1302	855	0.65
6.46	10.8	4	876	290	0.33
7.07	11.7	6	946	239	0.31
8.61	12.1	8	979	137	0.14

(Gill, et.al., page 263)

As a MB plow moves forward, its double wedging action exerts pressure both upward and toward the open furrow. Stresses set up by this action cause blocks of soils to be sheered loose at regular intervals on parallel, inclined shear planes. The soil blocks forward by the primary shearing action break down as they move up the MB, forming secondary sheer planes at right angle to primary ones. Further pulverization is caused by sliding of these blocks over each other. Vertical profiles in the central areas of pulverization of all MB could actually follow a curve $Z = ae^{bx}$. Because of inversion requirements, the upper portion would be steeper than this equation would indicate. Turning and inversion of furrow slice follows the principle of spiral easement curves.

The clod mean diameter decreased from 8.6 to 1.5 inches as the width of cut was reduced. The energy utilization factor, based upon drop-shatter method increased from 0.14 with an 8-inch cut to 0.65 with 2-inch cut and 0.79 with 1-inch cut. Data by Gill and McCreery is given in **Table 8.** **Table 8** shows that increase in width of cut causes increase in clod size. For a high degree of pulverization, smaller width of cut is beneficial. High specific draft of small width of cut is not a problem if soil must be further tilled to produce a small clod size.

Chisel plow does not invert the soil but this only stirs the soil at shallow depth as discussed earlier. It has less pulverization action.

Table 9. Speed vs clod size

Silty clay loam		Silt loam	
Speed, mpt	Clods (19.2 mm in dia.)	Speed, mpt	Clods (19.2 mm in dia.)
1.8	31.7	3.1	8.3
2.5	30.8	3.8	5.8
3.1	28.2	4.3	5.3

(Gill, et.al., page 322).

Figure 163 (Ag. Handbook 316) describes a volume of soil disturbed by a simple chisel and chisel with wings. The shapes of soil blades formed on a straight chisel operating in sandy loam soil at various rake angles are discussed in Figure 129 (Ag. Handbook 316). Equation: S = A Cot ((e + e_o)/2 where S = Distance to reach depth, a = final equilibrium depth, e = clearance angle during operation and e_o = initial clearance angle at time of entry into soil; describes the Sineokov work for the length of path required for radial and parallelogram linkage hitch systems to reach an operating depth for simple chisels and sweeps. The mechanics of soil rupture in front of a chisel are discussed by Callaghan in "Compaction of Agricultural Soils". **Table 9** (Ag. Handbook 316, page 322) shows that the change in speed and soil breakup is insignificant for chisels.

Trash Incorporation and Insect Control

Fields often need tillage for crop residue management. It may involve plowing weeds under and crop residue to allow ease of planting. MB plow helps in burying trash in the soil to reduce weed competition with the future crop. Figure 230 (Ag. Handbook 316) shows how an MB plow places the surface residue in the soil. With an MB plow equipped with coulter and wire plowing 8-inch deep, plant material was placed in thick isolated bands so that continuity of the soil was retained throuth the profile. With a low speed MB at 4 inches, plant residue essentially isolates the plowed layer from the subsoil. It is considered superior to all other tools for covering the plant material because of its inversion action.

Chisel plow leaves the trash on the surface and, of course, cuts the weeds. Leaving the trash on the surface would mean more chances of insect-infestation and disease spread. But the surface residue helps to slow down soil erosion. The chisel plow is more suitable for weed control due to shallow row cultivation. The tines uproot the smaller weeds and break any crust that might be present without any injury to seedlings. Cotton-root rot and white mold on peanuts are controlled by deep plowing. One can chisel plow in fall after harvest to open the soil in order to accept more water over winter. Spring chiselling followed by discing breaks up the residue from previous chiselling followed by discing breads up the residue from previous year's crop so that plant clogging is not a major problem. For heavier soils, it is recommended to use MB plow once every 3–4 years.

Table 10. Characteristics of tillage systems

Quality	MB plow	Chisel plow	Till-plant
1. Time and labour demand	most	moderate	low
2. Fuel consumption	greatest	moderate	low
3. Dependence on herbicides	least	intermediate	intermediate
4. Erosion control	poorest	-do-	-do-
5. Opportunity to double crop	poorest	fair	fair
6. Requires learning new tech.	least	intermediate	high
7. Support traffic during wet harvest season	least	least	good
8. Adaptable to poor drained soil	best	good	good
9. Minimize insect and disease problems	best	good	intermediate
10. Special planter required	no	no	yes

(The Ohio Farmer, Mar. 19, '77).

Conclusion

Chisel plowing, in certain cases, offers a high capacity, low-cost alternative to MB plowing. One should match both the implement and its use to ones field requirements. Quality characteristics are given in **Table 10.** Energy required to pull the chisel plow is less than for MB plow and chiselling is more economical. From the technical review above, it is concluded that chiselling is better than MB plowing in Midwest U.S.

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Determination of the Design Capacity of Irrigation Systems Through Extreme Evaporation Technique

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Abstract

Extreme evaporation occurences were evaluated for 11 stations in Washington State, U.S.A. where 15 or more years of useable records had been taken. Evaluations were made by applying the theory of extreme values (Fisher-Tippet Type I distribution), and the equations for the best fit line describing each function were obtained by the method of least squares. These functions can be interpreted into design capacities of irrigation systems.

The above mentioned 11 stations at the 10-percent level of significance fell into three sub--groups having the same extreme evaporation functions.

Introduction

Water is usually a constraint for the adequate production of crops. It is, therefore, essential that the farmers must be informed about the water needs of each variety of crop and frequency of irrigation. As new varieties of different crops are a frequent phenomenon, it is desirable to search for a method by means of which the water requirements of the new variety can be easily determined.

Various approaches have been proposed for estimating the consumptive use of water by crops. The effects of temperature, humidity wind velocity, vapor pressure and solar radiation on the consumptive use of crops have been studied. Jensen et al (1961) reported that evaporation from a weather bureau pan is a good index of consumptive use. They established values of near constant relationships which existed between consumptive use for various crops an evaporation in Central Washington.

Jesen and King (3) published a method for establishing the frequency and magnitude of evaporation extremes from relatively long periods of records and for interpreting these evaporation extreme occurrences into consumptive use occurences. The frequency and magnitude of maximum consumptive use rates were interpreted into irrigation system design capacities. The statistical theory of extreme values (Fisher-Tippet Type I distribution) was applied to determine the frequency and magnitude of the evaporation extremes.

The purpose of this study was to evaluate the evaporation extreme functions for the 11 weather stations in Washington where useable evaporation records have been taken and to establish zones in Washington where useable evaporation extreme functions are similar. This information facilitated the determination of design capacities for irrigation systems represented by the stations studied.

Material and Methods

Useable evaporation records of the stations in Washington available for 15 or more years were studied. Daily evaporation data of all stations had been taken with a 4-foot weather bureau class A pan except at Prosser where records were taken from a 6-foot ground pan. To bring the data of all of the stations on comparable basis the observations at Prosser were converted to USWB 4-foot pan basis by multiplying them by 1.36, as suggested by Pruitt (5).

Evaporation data for June, July and August were used in this study as Jensen and King (3) had concluded that all periods of evaporation maximum in Washington fell within these months.

The weather stations and their corresponding number of years of complete and reliable records given (in brackets) are: Lake Kachess (29); Lind (30); Moses Lake (15); Othello (22); Prosser (32); Quincy (21); Rim Rock (16); Seattle (19); Walla Walla (Ent Lab.) 3W (20); Walla Walla (G.C.H.) (26); Wind River (30).

Evaluations were made by applying the theory of extreme values (Fisher-Tippett type distribution) and the equations for the best fit lines describing each function were obtained by method of least squares (1,2). The equation of best fit line of Magnuson (4) was rearranged as $x/\bar{x} = 1 + (c/\sigma n)(y - yn) \cdots (1)$ where c is the coefficient of variance and was expressed by $c = (\frac{1}{n-1})\,(\Sigma\,(x/\bar{x})^2 - n)^{1/2}$: x is the extreme evaporation; x is the mean of annual evaporation extremes; n is the number of years of record used; yn is reduced mean; σn is the standard deviation of reduced extremes; y denotes the reduced variate, n and yn are theoratical quantities depending only on sample size.

Equation (1) can be arranged as $y = (\sigma n/c)(\frac{x}{\bar{x}}) - (\sigma n/c) + yn$. The equation of the best fit line is plotted on the extreme probability paper and the values of $x/\bar{x}$ are read for 2, 5, 10 and 20 years frequency of occurrence.

The useable soil moisture reservoir capacity for any soil in Washington is insufficient to last a month during the peak consumptive use period. To examine the extreme evaporation functions from one day to 30 consecutive days, analyses were made to determine annual extreme quantities for 1, 2, 3, 4, 5, 7, 10, 20, 25 and 30 consecutive day periods. The frequency of occurrences examined were arbitrarily selected as 2, 5, 10 and 20 years conforming to the frequencies used by Jensen and King (3).

To study the similarity of evaporation extreme functions the stations were arbitrarily divided into two groups, one group with warm and high evaporation values and the other with cooler and relatively lower ecaporation rates.

As these stations were located in irrigated, semi-dryland and dryland evironments, the original evaporation records were adjusted to an irrigated evaporation environment to bring the data on comparable basis. For this purpose the evaporation values at dryland and semi-dryland stations were multiplied by 0.775 and 0.887, respectively, as suggested by Pruitt (5).

For comparison of the extreme functions for different stations, the 10-day extremes were used. This choice was based on the thought that 10-day was a sufficiently long period; to minimize influences caused by possible error in a daily observation but not so long as to observe variations real for a relatively short period. The correlation coefficient (r) was determined between every two stations of a group to determine if the trends were similar. Evaporation values for 10-day extremes for 2, 3, 4, 5, 6, 7, 8, 9, 10, 15 and 20 years, frequency of occurrence were computed. These values formed a sample for one station. Similar samples were found for all stations as the values of correlation coefficient (r) between different stations were determined.

Confidence intervals were established on the mean values for 10-day extremes for each station at 0.1, 1.5, and 10 per cent levels of significance to establish whether the stations in a group belonged to the same population. Samples were the same as used to determine correlation coefficients. Each station interval was compared with every other station in the group and functions whose intervals overlapped belonged to the same population. Those whose intervals did not overlap belonged to different populations at the specified level of significance.

Results and Discussion

Fig. 1 gives the plots of the average daily evaporations vs eva-

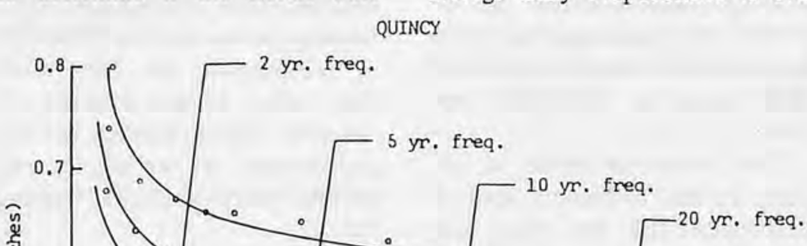

Fig. 1 Average daily evaporation during the maximum evaporation periods vs evaporation maximum for the cumulative day periods for 2, 5, 10, and 20 year frequencies of occurrence for Quincy.

Table 1. Values of Correlation Coefficient "r" for Stations in Group 1 (Calculated from 10 Consecutive-Day Period Extremes of Evaporation)

Station	Lind	Mosses Lake	Othello	Prosser	Quincy	Walla Walla (E. Lab.)	Walla Walla (G.C.H.)
Lind	1.000	0.998	0.988	0.947	0.994	0.996	0.997
Mosses Lake	0.998	1.000	0.989	0.943	0.999	0.998	0.998
Othello	0.998	0.989	1.000	0.992	0.997	0.995	0.993
Prosser	0.947	0.943	0.992	1.000	0.997	0.997	0.946
Quincy	0.994	0.999	0.997	0.997	1.000	0.998	0.997
Walla Walla (Ent. Lab)	0.996	0.998	0.995	0.997	0.998	1.000	0.999
Walla Walla (G.C.H.)	0.997	0.998	0.993	0.996	0.997	0.999	1.000

Table 2. Values of Correlation Coefficient "r" for Stations in Group 2 (Calculated from 10 Consecutive-Day Period Extremes of Evaporation)

Station	Lake Kachess	Wind River	Seattle	Rim Rock
Lake Kaches	1.000	0.873	0.998	0.993
Wind River	0.873	1.000	0.870	0.873
Seattle	0.998	0.870	1.000	0.998
Rim Rock	0.993	0.873	0.998	1.000

Table 3. Confidence Intervals on the Means for Different Stations in Group 1 (Computed for 10 Consecutive-Day Period Extremes of Evaporation.)

Station	Σx^a	$\bar{x}^b$	Σx^2	s^{2c}	$s_{\bar{x}}$	Confidence Intervals			
						99.9%	99%	95%	90%
Lind	41.79	3.80	0.058	0.580	0.073	4.14–3.47	4.03–3.57	3.96–3.64	3.93–3.67
Mosses Lake	45.82	4.165	1.53	0.153	0.118	4.71–3.62	4.54–3.79	4.43–3.90	4.38–3.95
Othello	43.15	3.923	0.455	0.0455	0.064	4.22–3.63	4.13–3.72	4.07–3.78	4.04–3.81
Prosser	49.37	4.488	0.794	0.0794	0.085	4.88–4.10	4.76–4.22	4.68–4.30	4.64–4.33
Quincy	46.48	4.225	1.72	0.172	0.125	4.80–3.65	4.62–3.83	4.50–3.95	4.45–4.00
Walla Walla (Ent. Lab.)	43.42	3.947	0.403	0.0403	0.061	4.34–3.67	4.14–3.75	4.08–3.81	4.06–3.84
Walla Walla (G.C.H.)	43.64	3.967	0.620	0.062	0.075	4.31–3.62	4.21–3.73	4.13–3.80	4.10–3.83

a Σx is the sum of all observations in the sample in inches.
b $\bar{x}$ is the sample mean, Σx^2 is the sum of squared deviations from the mean.
c s^2 denotes sample variance and $s_{\bar{x}}$ is the standard error of the mean.

Table 4. Confidence Intervals on the Means for Different Stations in Group 2 (Computed for 10 Consecutive-Day Period Extremes of Evaporation.)

Station	Σx^a	$\bar{x}^b$	Σx^2	s^{2c}	$s_{\bar{x}}$	Confidence Interval (95%)
Lake Kachess	32.22	2.93	0.311	0.0311	0.053	3.05–2.81
Rim Rock	32.33	2.94	0.235	0.0235	0.046	3.04–2.84
Seattle (Maple Leaf)	32.24	3.113	0.675	0.0675	0.078	3.29–2.94
Wind River	32.58	2.962	0.420	0.042	0.062	3.10–2.82

a Σx is sum of all observations in the sample in inches.
b $\bar{x}$ is the sample mean, Σx^2 is the sum of squared deviations from the mean.
c s^2 denotes sample variance and $s_{\bar{x}}$ is the standard error of the mean.

poration maximums for cumulative day periods. This information can be utilized for establishing irrigation system capacity. A maximum evaporation value is multiplied with Kc, the crop factor for a specific crop, to yield the design consumptive use value for the consecutive-day period and frequency of occurrence. The design average daily consumptive use is calculated by dividing the total design consumptive use by the number of days in the consecutive day period for the frequency of occurrence. Maximum consumptive use for each commulative day period can be plotted against daily consumptive use for the period to yield the design consumptive use function. Thus a family of curves were developed for each frequency of occurrence for the crops to be grown. These curves provide rationally estimated maximum consumptive use rates which will be experienced only once, on the average, in the frequency number of years.

The correlation coefficient (r) for stations in group 1 (Table 1) varied from 0.999 to 0.922, indicating a degree of very high correlation between these stations. Values of r for the Group 2 stations (Table 2) varied from 0.998 to 0.870 showing a degree of high correlation. Hence the evaporation extremes increase or decrease in a similar way from one station to another within each group.

The confidence intervals comparing date between stations for those in Group 1 at 0.1, 1, 5 and 10 per cent levels of significance (Table 3) shows that all station in the group belong to the same population at the 0.1 level of significance, i.e., the difference in their means are not significant at that level. At 1 and 5 per cent levels of significance, Prosser was significantly different from Lind, Othello, Walla Walla (Ent Lab.) and Walla Walla (G.C.H.), but belonged to the same population as Quincy and Moses lakes. This information indicates that one extreme function should be used for Prosser. Quincy, and Moses Lake and another extreme function should be used for Lind, Othello, Walla Walla (Ent Lab.) and Walla Walla (G.C.H.).

At 10 per cent level of significance, all the stations fell into three sub-groups with differences in each sub-group being non-significant. This means that stations in each sub-group belong to the same population. These sub-groups are Lind, Othello, Walla Walla (Ent Lab.) and Walla Walla (G.C.H.); Prossr, Quincy, and Moses Lake; and Othello, Moses Lake, Quincy, Walla Walla (Ent Lab.) and Walla Walla (G.C.H.)

All stations in Group 2 belong to the same population at 5 per cent level of significance. The confidence interval of Group 2 (Table 4) indicates that one extreme evaporation function will be adequate to design an irrigation system for all stations in Group 2.

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Recent Morphological Changes in the Ganges River

by
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Abstract

Some of the major rivers in Bangladesh are undergoing great morphological changes. The present study was undertaken to quantify such changes for the reach of the Ganges from Rajshahi to Gualunde. Data for this 129-km reach of the Ganges were collected from different offices of the Bangladesh Water Development Board and analyzed.

It was observed that the thalweg sinuosities in the reach of the river were 1.19 and 1.15 in 1968 and 1969, respectively, and its value reduced to 1.09 and 1976. The river is gradually becoming straight and developing braiding.

The study also shows that the river is gradually becoming flatter, wider, shallower and the braided pattern is emerging in some reaches in placed of meandering pattern.

Introduction

Bangladesh is a land of rivers interlaced by numerous channels of the three great river systems; the Ganges-padma, the Brahmaputra-Jamuna ad the Meghna. The Ganges is an international river, with its basin spread over China, Nepal, India and Bangladesh.

Since ancient times the river has meandered extensively. Often, it leaves the old bed and seeks a new channel. New islands are washed away or attach themselves to the main land. Many ruins of old towns and cities are evidence of such changes. (NEDECO, 1967) It floods the flood plain. Another source of misery is the erosion of banks which brings in destruction of lives and properties, damage of engineering works, etc. A study of the morphogical characteristics is extremely important in connection with river bank stabilization, navigation, etc. Before taking any river training works, it is required to know the behaviour of the river. Hence, this study of recent morphological changes in the Ganges.

River Patterns

The pattern of a river is defined as the appearance of a reach in plan view. If plan views of most of the major rivers are examined they can generally be grouped into three types: straight, meandering and braided. Straight rivers are those which have, at the bank-full stage, a negligible sinuosity over a distance many times the channel width.

The term meandering is generally applied to any river having a sinuous course, with bends of either regular or irregular shape and small or large curvature. Meanders can be classified as either of regular or irregular shape and as either simple or compound. Regular meanders are a train of bends of the same curvature and frequency. Irregular meanders are deformed in shape and may vary in amplitude and frequency.

Braided rivers are those marked by successive divisions and rejoinings of the flow around alluvial islands. In this case the channel is wide, the banks are poorly defined and unstable.

Data Collection and Analysis

The Bangladesh Water development Board (BWDB) was responsible for the collection of data from cross-sections along the river at 21 places. The sections were taken only during low-water period. The complete set of data available for 1967, 1968, 1969 and 1976 were analyzed for this study. The cross-section of the Ganges River ranges from G#18 located at the point of entry into Bangladesh to G#0-1 located at Goalundo have been plotted. With a maximum depth at each cross-section for each of the four-periods, the thalweg were determined. The locations of the right bank and left bank were drawn by studying all the cross section ranges from G#18 to G#0-1 which show the shifting pattern of the Ganges river.

The sinuousity ratios, i.e., length along river bend to straight length along the chord was computed from the thalweg of respective years and were determined at various places in the reach of the river. Curves were drawn for 1976 and 1969 to obtain the relationship between sinuosity and channel shape (Fig. 1). In a similar way, the relationship between sinuosity and slope (Fig. 2) and the relationship between sinuosity and time were plotted (Fig. 3).

The short term changes of river banks and comparative bank line studies were also done. The superimposed cross-section for different years were studied to quantify the movement of sand bars, shoals and resulting changes in the cross-section.

Discussion

Fig. 1 shows the relationship between sinuosity and channel shape for 1969 and 1976. It appears that channels with low sinuosity have wide and shallow cross-sections.

The relationship between sinuosity and slope also shows that the channels with low sinuosity have steeper slopes causing a wide, shallow channel in which bars and islands readily form. For the wide and shallow cross-section, the banks are poorly defined and unstable. Numerous sand bars and islands produce sub-channels which rapidly change position with time and stage and in an unpredictable manner. The result of this constant change in cross sectional area is rapid cutting and filling along the banks. Thus the bank lines of most braided rivers are indistinct. Braided rivers may develop if the stream is supplied with more sediment than it can

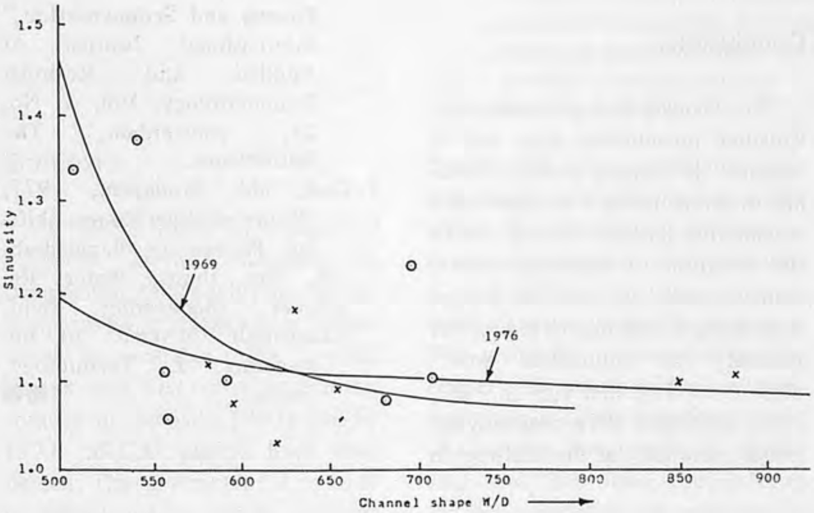

Fig. 1 Relationship Between Sinuosity and Channel Shape

Fig. 2 Relationship Between Sinuosity and Bed Slope, 1969 and 1976

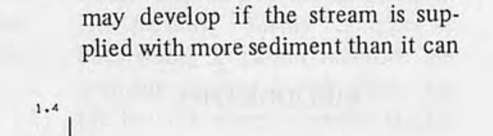

Fig. 3 Variation of Thalweg Sinuosity Between 1967 and 1976

Table 1. Morphological Charges in the Ganges River

Year	Ganges River Range	Total Length Along River Bond (m)	Straight Length of River (m)	Thalweg Sinuosity
1967	G # 18-G # 1	119,094.78	100,248.09	1.19
1968	"	119,495.58	100,248.09	1.19
1969	"	115,485.82	100,248.09	1.15
1976	"	109,470.89	100,248.09	1.09

carry and part of it is deposited. At steeper slopes the sinuosity is also unity but in this case the channel is braided. Fig. 3 shows the variation of thalweg sinuosity from 1969 to 1976. It is observed from Table 1 and Fig. 3 that the thalweg sinuosity between cross-section G#18 to G#1 were 1.188, 1.19, 1.15 and 1.09 in 1967, 1968, 1969 and 1976, respectively. Thus the thalweg sinuosity of the reach of the Ganges under consideration is decreased gradually, which means that the river is developing straight-braided pattern. In the low-wate stage, prior to the passage of flood, the river is sub-divided into numerous small channels, with one of these generally serving as main channel and carrying a large portion of the flow. Thus the thalweg shifts continously from one position to another within the bank lines with the passage of floods and it is affected most by the variability in the flow and by bank conditions. Also, the discharge, channel geometry, and channel conditions all combine to determine the general trends in further development of the channel.

Conclusions

The Ganges is a predominantly irregular meandering river and is recently developing straight braiding in some reaches in place of a meandering pattern. This is due to the variation of discharge, movement of sand bars, etc. The Ganges is showing a tendency to reduce her sinuosity. The sinuosities were 1.19, 1.19, 1.15 and 1.09 in 1967, 1968, 1969 and 1976, respectively. Hence, sinuosity of the thalweg, in general, is becoming straight. A river with low sinuosity has wide and shallow cross-section, steeper bed slopes and more likely to produce a braided form.

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Determination of the Design Capacity of Irrigation Systems

(Continued from page 59)

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Socio-Economic Factors Affecting Low-Lift Diesel Engine Pumps Irrigation Machinery in Bangladesh

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Summary

Of the 3 types of mechanical irrigation method available in Bangladesh, the low-lift pumps are in operation in places where surface water is available. The low-lift pumps were first introduced in this country in the early 1960's and by 1979, 39,000 pumps have been fielded. The government is presently subsidizing a 2-cusec low lift pump set at the rate of 75%. However, the irrigation coverage per pump has been rather low and according to a study, only 39.76% of the capacity is being utilized. Various technical and socio-economic factors are responsible for such low capacity utilization of the pump sets.

The present pattern of land ownership and existing tenancy conditions are affecting the capacity utilization of the pump sets. Studies have shown that farmers having lands up to 2.5 acres are the most progressive in adopting modern technology. Formation of the managing committees and selection of site for fielding the pump sets have direct bearing on the capacity utilization. Scarcity of water, irregular supply of fuel, shortage of spare parts and poor maintenance of the machines also affect the capacity of utilization. Inadequate provision of institutional credit often discourages farmers from adopting irrigation practices. Non-availability of irrigable land in cluster also results in the low acreage coverage of the pump sets.

Changing the pattern of ownership and improving the existing tenancy conditions are expected to have considerable effect on the capacity utilisation of the pumps. Provision of institutional credit, timely supply of fuel and spare parts and undertaking of land-levelling measures may contribute favourably to the capacity utilisation of pump sets.

Introduction

Bangladesh experiences on an average more than 80 inches of rainfall annually. Of this, more than 90 per cent occurs during the monsoon months of May to October and Bangladesh's two main rice crops (Aus and Aman variety) are grown rainfed during this period. The remaining 6 months of the year remain virtually dry. A third crop, i.e., Boro variety of rice, is grown during the period with the help of supplemental irrigation. In the low-lying lands (haors, beels, etc.) and inthe rivers sufficient surface water is available with which this crop is raised.

A very rapid progress in agricultural production, particularly grain production, is of utmost importance for Bangladesh to feed its increasing population. It is realised that to attain this goal, along with improved variety seeds and fertilizer, irrigation facilities must be made available to raise an additional crop in the drought season. At present, mainly 3 types of mechanical irrigation methods are available in Bangladesh. They are the low-lift pump irrigation (LLP), deep tube-well (DTW) irrigation and shallow tube-well (STW) irrigation. The low-lift pumps are in existence in places where surface water is available.

Background

The low-lift pump irrigation scheme was first introduced in the early 1960's and more emphasis was given to it during the middle of

1960's. Up to June, 1973, 30,000 low-lift pumps were fielded and an estimated one million acres were being irrigated. The First Five – Year Plan (1973-78), of Bangladesh envisaged to field 45,000 low-lift pumps, of which 39,000 pumps were actually fielded up to June, 1978. Of course, the present available hydrological data permit the fielding of about 45,000 2 cusec low-lift pumps. To popularize low-lift pump irrigation in the country, the Government is highly subsidizing the scheme. In 1970-71, the Government subsidized a 2 cusec pump-set at the rate of TK 75 per unit (1). At present, the rate of subsidy is being continued at more or less the same rate.

The Pump

Diesel-engined pump sets are used for low-lift pump irrigation in Bangladesh. Pump sets may be of different capacities, viz. 1, 2, 3 and 4 cusecs. However, the most common and popular type is the 2 cusec pumps.

The pump sets are procured and owned by the Bangladesh Agricultural Development Corporation (BADC). Every year at the beginning of the Boro season, the agency rent them out to selected group of farmers raising the crop. The groups pay a rental for the service of the pump set.

Utilization Rates

The irrigation coverage per unit of pump has been rather unsatisfactory. The following table shows the increase in the number of pump sets fielded and the corresponding increase in acreage covered between 1965 and 1971-72.

Table 1. Trend in Pump Set Use and Area Irrigated

Item	1965–66	1971–72	Percent Increase
Number of pump sets fielded during year	3,420	25,000	730
Area irrigated during year (in million acres)	.173	.882	510

Source: Alam, Mahmudul. Capacity utilisation of low-lift pump irrigation in Bangladesh.

The First Five-Year Plan envisaged a command area of 50 acres each for the low lift. However, according to a study (I) the command area for low-lift pump has been found to be 19.88 acres which is about 40 per cent of the target acreage.

According to the same study, the rate of utilisation differs considerably from area to area. About 10 per cent of the capacity is being utilized in sylhet which is, of course, the lowest. The highest rate of utilization has been found in Itna, Mymensingh, which is about 49 per cent. The study has observed a very low rate of utilization for Chittagong, Rangamati, Dohazari, Chandpur and Perozepur zones being 12, 11, 13, 12 and 12 per cent, respectively. There are, of course, some areas like Rajshahi, Dinajpur, Pabna, Bogra, Rangpur, Faridpur and Kusthia which have appreciable degree of utilization which are 28, 34, 41, 45, 36, 34 and 35 per cent, respectively.

Socio-economic Factors Affecting Utilization

Factors affecting the low capacity utilization of LLPs' in Bangladesh are both of technical and social and economic in nature. This paper is particularly concerned with the socio-economic aspects of the factors affecting low utilization rates.

Subsistence and big farmers

Agricultural productivity in Bangladesh is characterised by subsistence-level farming. More than 50 per cent of the farm households having owned and rented holdings, including share croppers of less than 2.5 acres have an income lower than the average (1).

According to a study (5), the cropping intensity, labour intensity and per acre yield of small farmers (less than 2.5 acres) are relatively higher than the average. In adopting new technology, e.g., improved variety seed, water and fertilizer technology, this class has come out as the pioneers. This has been substantiated by a study of crop-cutting survey carried out by Bangladesh Academy For Rural Development (BARD) which shows that small farmers (owning holdings upto 1.33 acres) were the most progressive with respect to adoption of improved practices.

But large farmers in the size-group of 2.5 acres and above own about 70 per cent of the farm area. Relatively large farmers adopted the new technology when the cropping with the new adopters stabilize. Otherwise, these farmers remain satisfied with whatever extra income they get by share-cropping or renting out some land (in cases where demand for their land from subsistence farmers exist) during the dry season. Therefore, the utilization rate of the pumps is significantly influenced by the rate of adoption of irrigation by the large farmers.

Cost Sharing of Irrigation Water

More tnan 60% of the members of the irrigation groups are share-croppers. (2) But the cost of irrigation water is entirely borne by the share croppers while the landlords receive half of the produce as their share. This discourages the share croppers to join the irrigation groups.

Selection of site

Selection of site of an irrigation unit is very important from the technical point of view. Actual coverage depends largely on the site where the irrigation unit is actually installed. But in many cases technical consideration is underplayed and some other considerations act strongly in favour of the selection of sites. Very often local power structure and vested interest influence the selection of sites, which in turn affects the capacity utilization of pumps.

Scarcity of water

In a number of cases, the actual coverage could not be increased due to scarcity of water or the limitation of surface water. Pump sets have been fielded in places where sufficient surface water to run these machines do not exist. In many northern districts scarcity of water makes it difficult to run the pump sets for desired hours. In many cases, loss of depth of streams or rivers has caused low utilization rates of pump sets. Every year due to sedimentation, some rivers and canals are increasingly being rendered incapacitated to hold sufficient water. Some areas in Savar thana of Dacca district which would grew the Boro crop a few years back cannot do it any more (1).

Managing committees

It was mentioned earlier that the pump sets are rented to farmer groups by BADC for irrigating their land. Each farmer group needs to have a managing committee to run the irrigation project. Mainly, two procedures are followed to form a managing committee. Managing committees are formed (i) through the initiative of local leaders and (ii) through the initiative of thana level Government institutions. In the latter case, officals from these institutions visit the field area and after talking to a few local leaders get the committee formed without consulting the farmers participating in the project. The societies or irrigation groups that are formed through the local initiative and leadership have been found to have covered average irrigated acreage higher than the average irrigation coverage of the pump sets under the managing committee formed through the initiative of government officers.

Supply of fuel and spare parts

It has been observed in a study (1) the that low availability of fuels at the time of transplanting affects the command area of pump sets. And, fuel crisis during the crucial flowering period (especially during milking stage) inhibits farmer's action vis-a-vis the future production plans. Irregularity in the availability of fuel has been observed to make irreparable losses. In Rajshahi in 1973, in the clay-dominant soil when water started flowing after some lapses, a large quantity of water was lost to seepage and, therefore, could not be utilized by the crop. It was further observed in the study that fuel supplied for consumption of the pump sets often do not meet the specification. It causes damage to the engine and therefore leads to frequent mechanical break-down.

Irregular supply of spare parts renders the pump sets unworkable even at the time of minor break-downs. This also affects the capacity utilization of the pumps.

Poor maintenance of machines

The machines are not properly maintained at the thana level workshop of BADC. These are returned for normal maintenance work resulting in frequent break-downs during the working season. This in turn, results in the low acreage coverage per unit of pump.

Non-availability of contiguous irrigable land

In Bangladesh, approximately even and long stretches of agricultural land is rare. A pump set can only serve those areas which are approximately at the same level. Irrigation losses due to percolation and seepage in the soil is less if the land commanded by a pump set is well clustered. Canals that are constructed serve only those areas adjacent to the water source.

Availability of credit

Availability of credit at reasonable rate of interest is an important factor in the acceptance of irrigation facilities by farmers. The effectiveness of irrigation water is largely dependent on the use of improved variety and fertilizer. Most farmers do not have enough money to purchase these inputs unless credit is available from institutional sources. Credit from non-institutional sources are available at a very high rate of interest and farmers are often discouraged to seek credit from these sources to buy modern inputs.

Partialities in distributing water

Most of the managing committees according to a study (2) were found to be dominated by relatives or big farmers themselves. Small farmers belonging to the groups complained that such managing committees showed favoritism in distributing water. The study further revealed that non-inclusion of areas of a neighbouring village in the irrigation unit even if the capacity of the machine was underutilized were also responsible for low capacity utilization of the low-lift pumps.

Irregularity in payment of dues

Farmers have been found to be irregular in paying thenecessary dues and cost of the fuel. This results in the late fielding and frequent stoppage of the machines.

Old machines

It was observed (2) that relatively older types of pumps were facing frequent disturbances and breakdowns. Shortage of spare parts aggravates the situation. It was observed in a study that those irrigation units which were installed within the four-year period of 1972-76 invariably gave a higher per unit coverage.

Pump operators

Pump operators of the LLPs are not well-trained. They are appointed after only 15 days of training. Their ignorance often results in the break-down of the machines. Moreover, they cannot even repair the minor fault and have to wait for the thana based mechanics to come to repair the minor faults. This results in the loss of time which s very vital.

Conclusion

The managing committee is a key factor and wherever this body performed its role honestly and with a purpose, the actual coverage tended to increase. The role of the managing committee should be to motivate the participating farmer-members, supervising intensively the machine and the members attached and inculcating group spirit. The committee should not be a monopoly of the big farmers only and the small farmers should be fairly represented in it.

The selection of the site should be on a more judicious basis. The possibility of shifting irrigation, i.e., shifting of the low-lift pump to different places of water source around the irrigation scheme should be explored. Measures should be taken so that the power structure and vested interest groups cannot influence the selection of site which invariably affects the actual coverage.

Irrigation water can be successful in raising productivity when it is supplied along with a package of inputs. Regular supply of the inputs like fertilizer, HYV seeds and other supplies, credit and other services must be made available at reasonable price and on time. Actual coverage tends to increase when supplies and services are available on time.

Setting up of small-scale industries for producing spare parts, etc, should be encouraged near the irrigated areas. Increase in supply due to indigenous production of some essential spare parts will give stimulus to adopting irrigation in large areas.

The Government should gradually encourage private ownership of pump sets. It will enhance the life-span of a pump set due to better maintenance. Pump sets of smaller capacity should be imported or produced more in large number in place of big ones.

Land levelling at certain places and excavation of canals will bring more areas under irrigation.

Motivation of the farmers to join irrigation groups should be an important objective. Specially, farmers near the already established pump sets should be motivated to join thegroup. This will ensure better utilization of pump sets.

The pump operators should be given longer training and they should be able to do some repair job.

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What Losses at the Threshing and Winnowing Stages

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Introduction

The problem of produce losses in agriculture has received little attention in developing countries in general, and in Pakistan, in particular, Whereas, a number of studies have highlighted the quantum of produce losses in agriculture, these studies have invariably disregarded the development of a sound methodological basis for the classification, location and indentification of factors accounting for losses in agricultural produce. The urgency of increasing food grain availability. finding out foodgrain substitutes and greater emphasis on the efficiency of resource use in agriculture, necessitates the minimisation of losses in foodgrains because of its possible contributions to the following:

i) It can assist to improve returns to the producer by increased availability of foodgrains.

ii) Raising present dietary standards.

iii) Improving food self – sufficiency prospects.

The focus of the present study is the determination of produce losses in wheat at the post-harvest stage of threshing and winnowing. The factors contributing to losses are manifold and varied. They range from biological, chemical, engineering and ecological in nature to imperfect market processes.

Wheat is the major staple crop of the country. It meets about 78 per cent of the total foodgrain requirements and contributes to nearly 82 per cent of the total protein needs obtained from cereals alone. As an important component of the consumers market-basket, both the urban and rural dwellers are extremely sensitive to wheat prices. A smaller volume of marketable surplus implies a sharp upward shift in wheat prices which greatly stimulates an upward rise in the prices of other commodities. Conversely, a large marketable surplus signifies lower wheat prices for the consumer and less dependence on food imports. Thus, the minimisation of produce losses is a vital step towards the augmentation of the net availability of foodgrains to the consumer and a mile-stone towards the achievement of the government to achieve food self-sufficiency, the goal has remained too elusive to be attained. Invariably the factors frustrating the attainment of this objective are the unregistered trade with neighbouring countries, shortage of irrigation water, lack of new high yielding crop varieties and occurrence of produce losses in one form or the other. It is with a view to quantitfying produce losses at the post-harvest stage of threshing and winnowing that the present study has been undertaken.

Methodology

In view of the diversity and heterogeneity of the universe, multistage sampling was practised involving the selection of "tehsils," villages, farmers and threshing floors. From the sampling stand point, the "tehsil" was found to be a concise administrative unit for which statistics on area and production are available. It was, therefore, chosen as the primary sampling unit. The tehsils were arranged in descending order on the basis of their respective contributions to the total production of wheat in the province. The tehsils were further stratified into low, medium and high producing categories called stratum A, B and C, respectively. Six tehsils in all were selected and divided as two from stratum A, three from stratum B and one from stratum C. (**Table 1**)

A sample of 2–3 villages from each tehsil was selected on the basis of judgement from the villages falling in 5–10 miles radius from the tehsil town centre. The villages were chosen keeping in view that all modes of threshing were included in the selected villages. The radius of five miles was ignored, because of the likelihood of preponderance of crops other than wheat, i.e., vegetables and fodders, near the tehsil town centre.

The selection of producers and threshing floors was carried out by

Table 1. Wheat Production Strata by Tehsils in the Punjab Province

Stratum	Range (Percent of weight)	No. of Tehsils	Percentage Contribution to Total Wheat the Province	No. of Tehsils Selected
A	Below 1.4	42	32.82	2
B	1.4 to below 2.8	26	52.70	3
C	Above 2.8	4	14.48	1
Total		72	100.00	6

a purposive sampling technique. In a preliminary survey, the producers falling in the sample villages were listed along with their threshing floors and modes of threshing. With a view to giving representation to bullock threshing, the producers who were most conveniently located and easily approachable were selected for the purpose of this study. Whereas, only three cases of mechanical threshing were selected comprising one each of tractor threshing, mechanical thresher were selected comprising one each of tractor threshing, mechanical thresher and combine harvestor subject to the availability of the latter. All six cases represented, different modes of threshing were selected.

The field data collection was carried out by a detailed questionnaire. To obtain more accurate data, the methods of personal interview and participant observation were employed and observations were recorded by repeated visits to the sampled threshing floors. In the first phase of data collection, the sampled farms were visited at the time of harvest and the following details were recorded:

i) Number of wheat fields per selected threshing floow;
ii) Area of selected fields in acres;
iii) Variety of wheat; and
iv) Yield in bundles.

A two-stage sampling technique was employed to record observations from the selected farms. A sample of five percent bundles per harvested field called "Sample bundles" was obtained. Similarly, five per cent sub-sample of the sampled bundles was taken denoted as "sub-sampled bundles". The sub-sampled bundles were threshed and winnowed under close supervision of the data recorder and the following observations were recorded:

i) Weight of sub-sampled bundles (w);
ii) Weight of grains obtained from sub-samples bundles. (g); and
iii) Weight of wheat straw of the sub-samples bundles. (s)

Visits were made by the researcher to the farmers' threshing floors and the information collected pertained to losses caused by rodents, birds, animals, pilferage, fire, wind storm and mechanical defect (for combine harvester and mechanical thresher only) which was based on the producers' opinion. For the estimation of losses due to insects, the average number of grains taken away per insect track per day and the number of days of insect attach were recorded with a view to estimating losses by fallen grains in the threshing floor. The area of threshing floor was measured in circular form. Three plots of one square foot each were selected at random. The soil was dug to 6 inches deep and the number of grains included in the sampled square foot area were counted. Fig. 1 (a).

Similarly, five plots of one square yard each were taken at random and the number of grains shreded down and the number of ears fallen were counted to estimate the losses taking place during the operation of the mechanical thresher Fig. 1(b).

The following formulas were applied to quantify losses caused by various factors:

1. Potential yield of grains

$$Yg = \frac{Gs \times 20 \times N}{n}$$

Where,
Yg = Potential yield of grains
Gs = Weight of grains in the sub-sampled bundles.
n = Number of sampled bundles.
N = Total number of bundles on the threshing floor.

2. Potential yield of straw

$$Ys = \frac{Ss \times 20 \times N}{n}$$

Where,
Ys = Potential yield of straw.
Ss = Weight of straw in sub-sampled bundles.

3. Loss caused by Insects

$$Li = \frac{Gi.\ Sw.\ T.\ P.\ I.}{t\ 1000}$$

Where,
Li = Loss caused by insects.
Gi = Number of grains taken away per insect track per unit of time.
T = Average working hours per insect track per day.
P = Period of attack (days)
I = No. of insect tracks.
t = Unit of time.

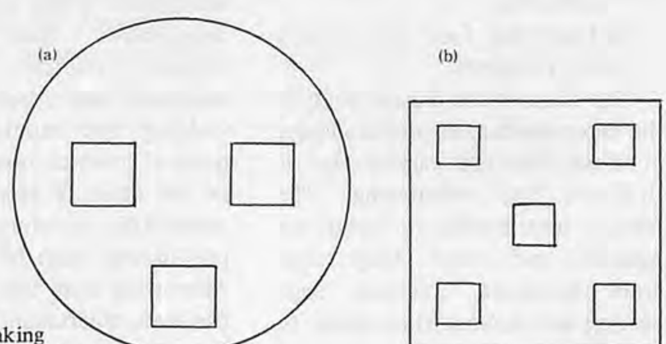

Fig. 1 Sample taking from threshing floors

4. Losses caused by grains in the threshing floor

$$Lt = \frac{Gt.\ r.\ II.\ Sw.}{2 \times 1000}$$

Where,

Lt = Losses caused by grains in the threshing floor.

Gt = Grains in the threshing floor per square foot.

r = Radius of threshing floor in feet.

Sw = Standard weight of 1000 grains.

$$II = \frac{22}{7}$$

5. Losses caused by grains in the straw

$$Ls = \frac{Gs.\ Ws}{s}$$

Where,

Ls = Loss cauesd by grains in the straw.

Gs = Average number of grains per sample of straw.

s = Weight of sample straw.

Ws = Total weight of straw.

6. Loss caused by shredding of grains

$$Lg = \frac{Gs.\ A.\ Sw}{1000}$$

Where,

Lg = Loss caused by shredding of grains.

Gs = Average number of grains shredded down per square yard.

A = Area of the field in sq. yard.

Sw = Standard weight of 1000 grains.

7. Loss caused by fallen ears

$$Le = \frac{Ef.\ A.\ Ge.\ Sw}{1000}$$

Where,

Le = Loss caused by fallen ears.

Ef = Average number of ears fallen per square yard.

A = Area of the field in square yards.

Ge = Average number of grains per ear.

Sw = Standard weight of 1000 grains.

8. Aggregate loss

$$L = Lr + Lb + Li + Lt + Ln + Ls + La + Lp + Lf + Lw$$

Where,

L = Aggregate loss.

Results and Discussion

A close scrutiny of grain losses at the threshing floor showed that the major factors accounting for losses comprised of rodents, birds, insects, rainfall, animals, pilferage, fire and wind storm, and the mode of threshing itself. In case of mechanical threshing, another factor was also noticed namely, the mechanical defect. Whereas, for the combine-harvester the factors included mechanical defect, grains shredded and the ears fallen in the field.

It is apparent from the statistics given below that losses in the case of bullock threshing, mechanical threshing, tractor threshing and combine harvester amounted to 3.11 per cent, 2.68 percent, 2.01 percent and 1.20 percent, respectively. (**Table 2**)

The below data highlights that the losses were maximum in the case of bullock threshing and minimum for combine harvester. Although the loss was minimum when combine harvester was used, but in view of the small size of holding, lack of technical staff, non-availability of wheat straw for animal consumption and, above all, high initial investment, the use of combine harvester was restricted.

Table 2. Distribution of Produce Losses in Wheat by Modes of Threshing

Mode of Threshing	Quantity Threshed	Quantity Lost	Percentage Loss
Bullock	1440.67	44.85	3.11
Mechanical	1782.67	47.79	2.68
Tractor	1018.42	20.45	2.01
Combine	120.00	1.50	1.50

The contribution of each factor responsible for loss towards total losses was also determined which is interpreted below (**Table 3**):

A review of the factors contributing to losses reflects that the winnowing loss, i.e., loss caused by mixing of grains in the straw, contributed more than 50 per cent. This loss was attributable to the nature and skill of labour employed and the weather conditions (wind effect) in the case of bullock threshing. In the case of mechanical thresher the skill of the operator and mechanical defects were responsible for winnowing losses. The loss was highly linked with the tenurial status of producers. The loss was relatively less in the case of onwer-operated farms.

It is apparent that the loss was greater in the case of tenants except for tractor threshing (**Table 4**). This may be attributed to the existing practise that the land is cultivated by tenants but threshing operations were performed by both the owners and tenants. The participation of owner makes the tenant to show extra efficiency and greater care in produce handling which resulted in less losses. The greater relative loss in the case of tenants was linked with the carelessness of the tenant. The relationship between tenancy and loss was non-significant statis-

Table 3. Factors Causing Losses During Threshing and Winnowing

Factors	Bullock	Tractor	Mechanical	Average
Winnowing	46.0	49.7	76.2	60.2
Threshing floor	18.5	17.4	7.4	13.2
Rodents	14.8	7.9	10.5	11.7
Birds	11.3	16.9	1.2	7.9
Rainfall	5.1	-	-	1.3
Insects	2.2	7.5	3.0	4.5
Wind storm	0.9	-	1.2	0.8
Animal	1.3	-	-	0.4

Table 4. Relationship of Tenurial Status with Threshing in the Sample Area (percentage loss)

Tenurial Status	Bullock	Tractor	Mechanical
Owner	2.83	2.12	2.55
Tenant	3.39	1.74	3.21

Table 5. Duration of Wheat Threshing and Winnowing (No. of days)

Mode	Pre-threshing	Threshing	Winnowing	Total
Bullock	16.2	8.9	9.2	34.3
Tractor	17.0	2.2	9.0	29.2
Mechanical	19.2	1.4	0.0	21.2
Average	17.5	4.3	6.1	27.9

tically.

Another factor aggravating loss was the time period spent on threshing and winnowing operations. It was observed that the longer the time period, the greater the magnitude of loss became.

As an average, the duration for threshing and winnowing operations was at 27.9 days. The minimum duration was that of bullock threshing and as already discussed, it also resulted in relatively greater loss.

The merits and demerits of various modes of threshing were also examined. In the case of bullock threshing less cost, easy availability and utilization of fixed costs incurred on bullocks by the farmers were risk of loss and comparatively deteriorated quality of produce. As regards two distinct modes of mechanical threshing and tractor threshing, the farmers listed their merits in the course of the survey as time saving devices and low risk of loss and higher comparative loss and non-availability at proper time were listed as their demerits. The cost of threshing, however, varied with each mode. The cost of harvesting, threshing and winnowing varied from Rs. 2.59, Rs. 2.21 and Rs. 1.31 per maund for bullock, tractor mechanical threshing and combine harvester, respectively. It was estimated that as an average 2.65 per cent of the potential production of wheat was lost during, harvesting, threshing and winnowing operations for all modes. In the Punjab case, the quantum of wheat losses was estimated around 1.51 lakh tons 1974–75 valued at Rs. 147.9 million ($ 14.9 million) which is of major economic importance for a poor and food deficit country like Pakistan.

Conclusions

1. The losses during threshing and winnowing by bullock threshing were estimated to be fairly high for tenants.

2. It was found that produce losses during threshing and winnowing are positively associated with the duration of threshing. From this stand-point, the mechanical thresher was found to have the least losses due to the shortest possible period required by it during the process of threshing.

3. Since grain losses are positively associated with threshing and winnowing, the losses tended to be highest in the case of bullock threshing.

4. The winnowing losses, as an average, accounted for more than 50 per cent of the total loss by each mode of threshing.

5. Rodents claimed the second highest loss in mechanical threshing, whereas, the threshing floor ranked as the second most important factor in grain losses taking place for bullock and tractor threshing.

6. In general, mechanical threshing had inflated losses due to the non-availability of repair facilities, existing mechanical defects and lack of proper maintenance.

Suggestions

1. Low cost, small-sized mechanical threshers must be provided to the farmers in order to encourage wheat threshing by this mode. It will involve low risk of produce loss, relatively reduced threshing period and as a time-saving device for the small farmers who very often make use of bullock threshing.

2. Repair facilities along with the adequate supply of spare parts must be made available in the rural area, with a view to minimizing losses taking place due to mechanical defects in the threshing machines.

3. Training facilities in the proper operation and maintenance of mechanical threshers should be provided to the farmers with a view to improving the present standards of thresher operation and maintenance.

4. Wheat threshing on a cooperative basis may be encouraged in the rural area. It will assist in minimizing the use of available machinery and labour and thus reduce the duration of over-all threshing period.

5. In view of higher losses occuring among the tenanted farms, it is suggested that participation and supervision of the owner may be encouraged during the harvest at post-harvest stages.

6. Rodent control is recommended for the avoidance of grain losses occuring not only during threshing and winnowing, but also during storage and in the standing field crops.

To this end, it is suggested that important places of rodent population may be determined and destroyed by the use of pesticides.

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Hand-Pullers of Cotton Stalks of the Gezira, Sudan

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Introduction

In Sudan cotton growing and its costs of production are of great national importance.

One of the difficulties in cotton production is the need to clear the ground from old cotton plants after harvesting. The main reason is to avoid the carry over of blackarm and leaf-curl diseases[7]. The cotton yield of the Gezira fell by 40 percent in 1930–31 below the long term average through an outbreak of the two diseases[1].

The ultimate goal calls for using machines to facilitate loosening of plant roots as a first step before collection of stalks[2, 8, 9]. Various types of pulling or root cutting units have been made, tried but discarded. Recently one type of pulling machine which uses the twin pneumatic tyres for uprooting of plant roots was set for durability tests in the Gezira, but still the current programmes to clear the cotton stalks in Gezira and other cotton irrigated projects depend completely on utilization of hand-pullers, as the case before 45 years.

After Bailey[3]; R. E. Massey in August 1932 designed a hand tool which was capable of pulling the old plants, roots and all from the soil. This type of hand tool was manufactured and used over the whole Gezira area at the end of the season 1932–1933 crop. Since that time, it became a standard practice after the crop has been picked, to up-root by hand all cotton stalks and to stack and burn them as a pest control measure[6]. Tenants are asked by law to clear their fields by the end of May, and for standard cleanliness any remaining bebris must be raked up and thrown onto the fires.

The hand-puller works on the pincer and lever theory, several sizes are seen today being used in the field, with a total estimated number of about 150 thousand units. The base of the hand-puller is made from a formed bar 3.8cm wide. A wooden stick is partly inserted in the pipe top-end. The handle is pivoted to the base at right angle and both base and the handle ends form the two gripping jaws. The base is rigidly connected by its rear side with the pressure plate. One labourer could complete the process of pulling-out one or a group of plants in one hole by means of the hand puller in a few seconds.

It seemed possible that some improvements could be made in the geometry of the tool in order to reduce required man effort.

Use of Mechanical Leverage Advantages on Hand-pullers

This depends on two leverage systems which reduce efforts: i) the pincer (a vertical flat gripping lever) and ii) pulling-out angled lever

In Fig. 1 if we assume :

- P_v The magnitude of vertical pull necessary to lift a plant (kg);
- P_h The magnitude of horizontal force necessary to grip the plant(kg);
- M_h The magnitude of human horizontal pull which produces enough grip(kg)
- M_p The magnitude of human horizontal pull which produces enough grip(kg);
- a. Gripping arm, distance between the pivot centre and jaw inner face centre (cm);
- h Convenient human working hight(cm);
- b Distance between human convenient working high and pivot centre(cm); and
- g Pulling arm which is the distance between the centre of gripped plant and the pressure plate point supported on the ground

Considering the flat lever (the pincer) as the pressure plate fully supported on the ground then:

$$M_h \cdot b = P_h \cdot a$$

$M_h = a/b \cdot P_h$

$M_h = \alpha \cdot P_h$

Where $\alpha = a/b$ = Gripping ratio of hand tool.

Through the pulling out step and

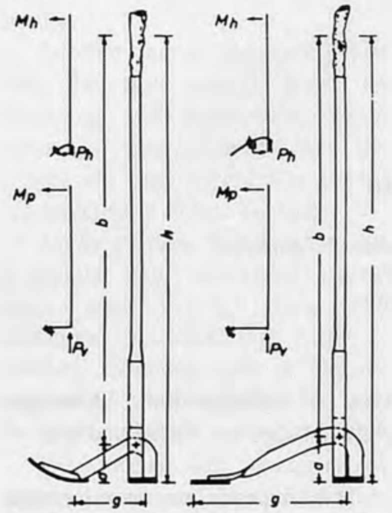

Fig. 1 Mechanical Leverage Systems of Both the variable-pulling arm and standard Gezira hand-pullers.

considering the bending movement about point X then :

$M_p \cdot h = P_v \cdot g$

$M_p = g/h \cdot P_v$

$= \beta \quad P_v$

Where $= g/h$ =pulling ratio of hand-puller.

The ratios α and β affect the magnitude of human effort and hence convenience and time rate of operation.

Development of New Hand-puller Version

Experiments on pull and lift required for a single plant have shown that the magnitude of maximum pull is 121 kg accompanied by a short lift of 4.9 cm were found necessary to loosen all plants completely[4].

Based on the standard Gezira hand-puller studies, Fig. 2, several experiments were done to modify it in order to minimize efforts required, and getting better out-put, by considering the following points.

i) Reducing the tool dead weight and hence the efforts of carrying the tool;
ii) Making use of the ideal mechanical leverage advantages (α and β ratios).
iii) Using double jaws from right and left sides to facilitate location on the stems;
iv) Reducing the inner jaw face are by serrations or sharpening to get better grip; and
v) To estimate the necessary area of the ground pressure plate.

The developed versions were :

1. Two pressure plates hand-puller (Fig. 4);
   a) With rectangular serrations

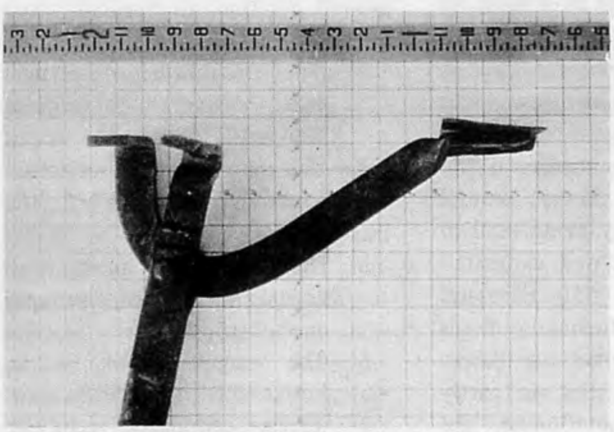

Fig. 2 The base of standard Gezira hand-puller (S.G.V.)

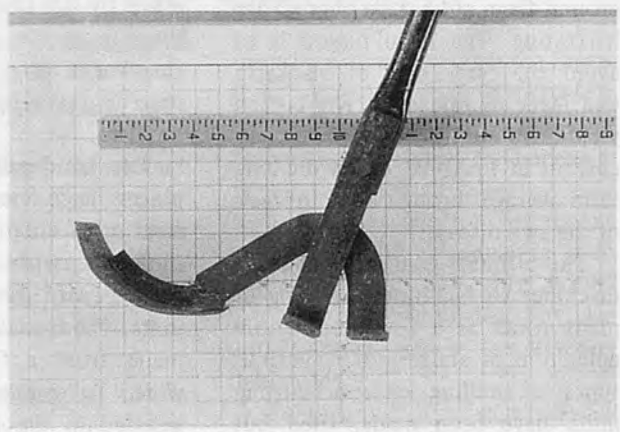

Fig. 3 The base of the prototype variable pulling-arm hand-puller (V.p.h.)

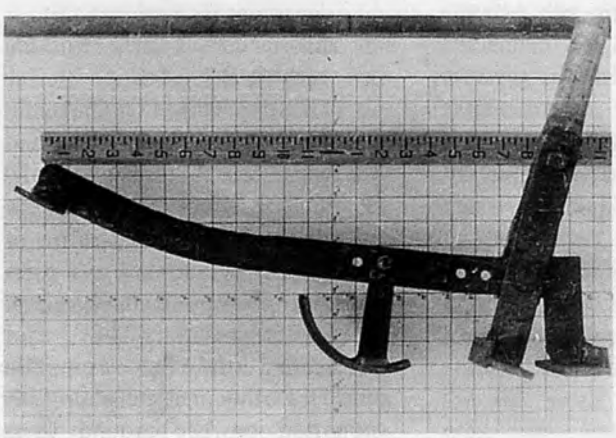

Fig. 4 The base of the two-support-type hand-puller

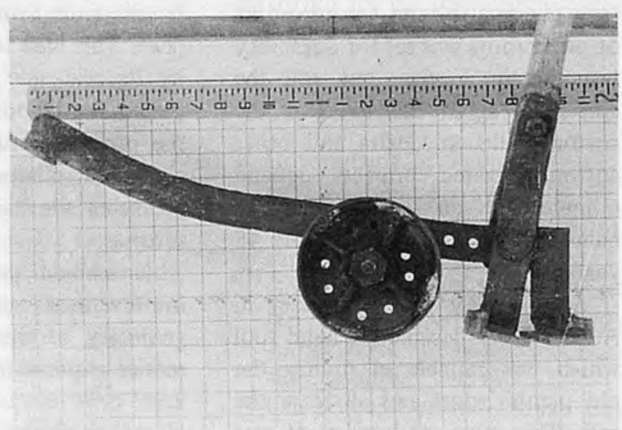

Fig. 5 The base of the wheeled type hand-puller

Fig. 6 A labourer using the V.p.h. to pull out cotton plants

on jaws; and

b) With 45 degrees sloped serrations on jaws.
c) With right and left hand jaws.

2. Wheel type hand-puller (Fig. 5) with rectangular serrations.
3. Variable pulling-arm hand-puller (V.p.h.), (Fig. 3, 6) with sharpened and rounded jaws inner face edges.

Preliminary Experiments

Certain modifications were carried out and were found not satisfactory to set for further trials. From these modifications the following pullers were assessed :

i) A puller with a base of reduced cross-section to lighten the tool. Not sufficient tool strength.
ii) Pullers with rectangular at triangular serrations on the gripping jaws. Not sufficient grip.
iii) A puller fitted with double gripping jaws on right and left sides. Additional jaws were found unnecessary.
A puller fitted with a small wheel for dragging the tool instead of carrying. Impossible to pull on rough and cracked soil.

Field Tests Procedure

From the above, the variable pulling-arm hand-puller (V.p.h.) with a variable fulcrum between 17.5–30 cm was further improved. This was tested in different numbers (unit of 10 feddans) and blocks (units of 90 feddans) in the Gezira in two successive seasons.

One or more labourers in each number were given the opportunity to use the V.p.h. instead of the S.G.h. for short time. After pulling out plants on several rows, they were asked to continue working by it. The time required to pull out plants in a number of rows was noted. Several rows were selected at random and plants on each row were counted. Height of plants, the general tool performance and soil disturbance were observed.

Comparative tests were done between the V.p.h. and the S.G.h. The same labourer was given the chance to use both hand-puller in the same field. Soil samples from the top 10 cm were collected for moisture determination. Weight and dimensions of the S.G.h. handed to the labourers who participated the experiments were measured and noted.

Observations

i) The average percentages of soil moisture content in different blooks were: 5.75, 6.97, 6.82, 5.68, 8.95, 15.81, 8.45

An increase in soil moisture of more than 8.00% was due to early showers during May.

ii) Average height of plants in field where experiments were done was found between 75–175 cm based on random measurements.
iii) A previous survey showed that the average number of plants was 135 per row which has a standard length of 20 meters, plant holes spacing is 44.4 cm and 3 plants per hole[6].
iv) The measured rates include normal intervals of rest.
v) The number of sheared plants and amount of soil lifted were about the same with both pullers.

Results and Discussion

Field experiments were done with the V.p.h. and the S.G.h. under the same field conditions, number of plants and by the same labourer. The collected data on rate of pulling one row was analyzed.

Comparison between the S.G.h. and V.p.h. rates of work

Table 1 Comparison of S.G.h and V.p.h. Performance

Puller	Average min/row	t test	Total No. of rows
S.G.h.	6.07	±0.97	190
V.p.h.	4.95	±0.59	382

1. A saving of 1.12 min./row was realized in the use of V.p.h. over that of the S.G.h which is equal to 22.6% reduction in the necessary time.

2. The big difference between the upper and lower limits for the S.G.h. = (2 × 0.97) indicates inconsistency in the performance of experimental S.G.h. (Different in service' age, conditions, weight and dimensions.)

3. The correlation between the V.p.h. and S.G.h. rates of work was positive but not significant (r= + 0.302).

Correlation between the rates of work of the V.p.h. and the S.G.h. and number of plants per row.

1. The coefficient of correlation r of the V.p.h. and number of plants per row = –0.192, is not significant.

2. The coefficient of correlation r of the S.G.h. and number of plants per row = + 0.43 that indicate a direct or positive correlation, it is not significant due to interference of other factors.

Difference in tools weight

Table 2. Difference in Tool Weights

	Pulling arm g cm	Grip-arm a cm	Tool weight kg	Convenient cm
S.G.h. (average of 29 units)	34	10	5.07	116
V.p.h. prototype	17–13	9	4.20	127
Difference in weight		=	0.87	

The V.p.h. is lighter by 0.87 kg. that that of the average of the S.G.h. This reduction in tool weight is equal to 17.15 percent, and is due to its smaller dimension (g & a) or a decrease in material, or a decrease in the maximum bending moment which could affect the cross sectional area, hence increase in tool strength.

General Discussions

It is difficult to make definite conclusions with this type of tool for limited experiments. However, the pulling of roots using a hand tool is slow, laborious, and tedious. If one considers the aspect of fitting the grip on a stem or more amongst several plants, then pulling and repeating, the effort of lifting the puller and carrying the tool, can on be irritating and tiring on a long hot summer day. Any effort to reduce the weight of the tool, ease the fit and the pull should be advantageous.

The S.G.h. is robust. The main advantage arising from the modifications are that the V.p.h. is lighter and the lift fulcrum is based on the requirements of plant lift.

Most of the labourers had said they prefer the V.p.h. to the S.G.h due to its better grip on the plant and the less effort required to pull.

Conclusion

The experiments with the variable pulling-arm and hand-puller tend to show that an improvement has been made and the rate of work has been increased.

Further improvement of the tool could be done, but this needs to be considered with regard to costs and durability.

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A Low Cost Solar Rice Dryer for Farmers in South-East Asia



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Summary

This paper describes a flat-bed dryer designed to enable the rice farmer in South-East Asia to dry his second crop in the wet season harvest. It holds ½ tonne of threshed paddy and has a simple solar air heater made from burnt rice husks and clear plastic sheet. The paddy can be dried in one or two days and is protected from rain. The cost of the demonstration unit was U.S.$ 120, this can be halved by using cheaper materials.

Introduction

The traditional methods used by farmers in South-East Asia to dry paddy in the sun after the harvest cannot be used for the second crop in the wet season because of the uncertainty in the weather. Cut paddy left in the field is liable to be spoiled by alternate rewetting and overdrying, which cracks the kernels and reduces the milling quality of the rice. Ordinarily, the farmer must sell his second crop quickly at a low price before it is spoiled. It would be to his advantage to dry his paddy immediately after harvesting so that he can obtain a better price for it, or store it safely for use at a later date.

The dryer described here was developed to meet this need. It has been designed so that it can be made by the farmer himself at a low cost with locally obtainable materials. A demonstration unit was built on a farm near the Asian Institute of Technology and was used by the farmer during September 1978. The farmer was able to dry his crop and sell it at a high price, and intends to build a larger unit himself in 1979. Other farmers in the neighbourhood have expressed their intention of building similar dryers for themselves, and the newspapers, radio, and television have shown considerable interest in the project.

The dryer could be used for other crops besides rice, such as peppercorns, shrimps, chillies, and coffee beans, and it is likely to find many applications in the South-East Asian region.

Technical Design

Fig. 1 shows how the dryer works. Sunlight passes through the clear plastic sheet and warms the air inside with the help of a layer of burnt rice husks covering the ground below to absorb the radiation. The warm air passes up through the bed of paddy and dries it. The chimney provides a tall column of warm air to increase the air flow through the bed by natural convection. If possible the air inlet at the bottom of the dryer should face the direction of the prevailing wind so as to further increase the air flow.

To dry paddy by the slow method one requires an air flow in the range 1 to 5 m^3/min per m^3 of grain (1). The air should be heated to reduce its relative humidity, but its temperature should not exceed 45°C otherwise cracking of the kernels will lower the head rice yield. If the ambient air temperature is 30°C and the temperature of the air inside the dryer is 40°C then a simple calculation shows that for a total height of the column of warm air inside the dryer of 4 m, the pressure difference across the bed of paddy is 1.46 Pa. The air flow through paddy is known to be 3 m/min for a pressure drop 100 Pa per metre depth of grain at low air flows (2). Therefore, assuming a grain depth of x m we obtain an air flow of $0.0438 \div x$ m/min, or $0.0438 \div x^2$ m^3/min per

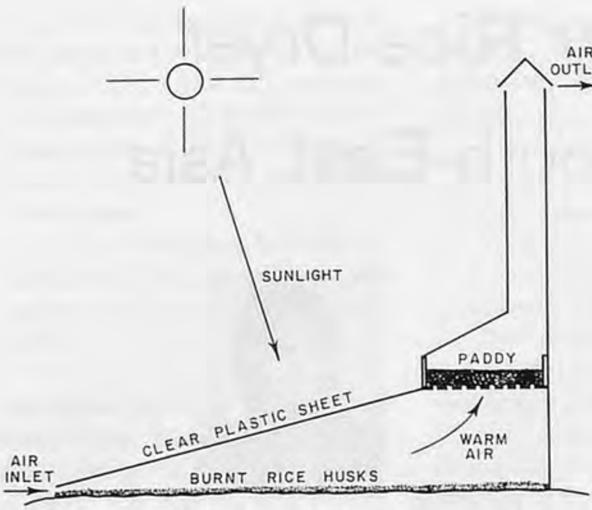

Fig. 1 Cross-section of dryer

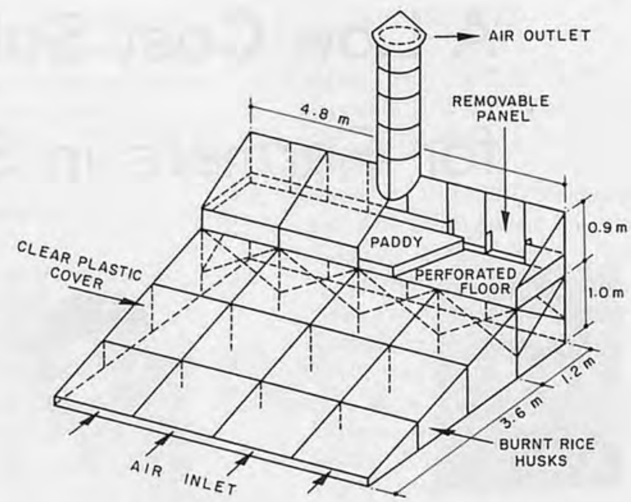

Fig. 2 Design of dryer

m^3 of grain for air flows in the required range 1 to 5 m^3/min per m^3 of grain mentioned above one finds from this formula grain depths from 209 mm to 94 mm. Preliminary tests have shown that a bed of depth 150 mm can be dried satisfactorily (3).

The amount of energy required to dry the paddy, and the intensity of the solar radiation, determine how big the solar air heater must be. On a poor day in the wet season the insolation is typically 15 MJ/m^2. To dry ½ tonne of paddy from an initial moisture content of 22% wet basis to a final moisture content of 14% wet basis for safe storage one needs about 120 MJ of energy to evaporate the water (4). Therefore, if drying in poor weather is allowed to take two days, and if the efficiency of the solar air heater is 25%, an area of 16 m^2 is required. The heater on our demonstration model has an area of 17.3 m^2.

Details of Construction

The main features of the design are shown in **Fig.** 2, and the photographs in **Figs.** 3 to 6 show what the dryer looks like.

The bed of paddy is contained in a shallow box 4.8 m long, 1.2 m wide, and 0.3 m deep. The bottom of the box is made of steel sheet 0.8 mm thick perforated with holes 1.5 mm in diameter, the holes occupying 30% of the floor area. The sides of the box are made of plywood. Removable panels at the back of the box allow the farmer to load and unload the paddy (**Fig. 5**). The box is supported 1.0 m above the ground on a strong wooden frame with secure foundations in the earth.

The area of ground covered with burnt rice husks in front of the rice bed is 4.8 m by 3.6 m. This area should be made convex so that pools of water do not collect there during rain. A drain cut around the dryer helps rainwater to escape.

The air spaces above and below the rice bed, and over the area of ground in front, are enclosed by clear plastic sheet 0.15 mm thick. The plastic sheet is supported by a framework of bamboo poles and wire. There should be no air leaks in the plastic cover; leaks will reduce the air flow through the rice bed.

The chimney consists of a bamboo frame covered with plastic sheet, which should be dark in colour to absorb heat from the sun. The chimney on the demonstration model has an extra layer of clear plastic sheet over the dark plastic, but this has now been found to be unnecessary. A cover over the chimney keeps out rain.

Fig. 3 Dryer under construction

Fig. 4 The completed dryer

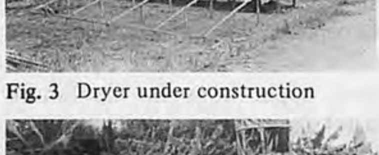

Fig. 5 The back shown open

Fig. 6 The rice bed

Method of Use

The newly threshed paddy is first cleaned to remove straw and chaff. It is then loaded into the box to make a layer 150 mm deep. The rice bed should not be deeper than 150 mm, otherwise not enough air will flow through it for satisfactory drying. The paddy will dry better if it is stirred several times during the day.

The paddy should not be heated above 45°C, otherwise the kernels will crack. If the inside of the dryer becomes too hot on a bright day, the cover should be shaded.

The time taken for the paddy to dry depends on the depth of the bed, the initial moisture content of the paddy, and the weather. If the paddy has already become partly dried during threshing and the weather is fine, drying will take one day. If the initial moisture content of the paddy is high and the weather is cloudy, drying may take several days. Even in dull weather the air inside the dryer will be warmer than the outside air, and slow drying will take place. During periods of rain the paddy in the dryer is safe and will not be spoiled.

If the total amount of paddy to be dried is several tonnes and only a single dryer of ½ tonne capacity as described here is available, the paddy should be harvested and dried in batches every few days. If all the paddy is harvested at the same time it cannot all be dried at once, and wet paddy waiting to be dried may be spoiled.

Quality of Product

Laboratory germination and milling tests on paddy dried in a small prototype unit last year showed (3) that the quality of paddy after drying by this method is high.

In the case of the germination tests the quality of the dried paddy was found to be over 90%.

In the milling tests the total yield, namely the total weight of whole and broken kernels obtained per unit weight of paddy was 70%. The head yield, namely the weight of unbroken kernels obtained per unit weight of paddy, was 58%. This is equal to the head yield from mechanically dried paddy, and is superior to the maximum head yield of 46% obtainable from paddy sun dried in the open air (5).

Cost

The materials for the construction of the demonstration unit cost 2,400 bahts, which is equivalent to U.S.$ 120. **Table 1** shows the costs of the individual items.

Table 1. Cost of Materials

Item	Baths	U.S.$
Perforated steel sheet	900	45
Wooden posts, plywood, and bamboo poles	900	45
plastic sheet	400	20
Wire nails, paint, etc.	200	10
Total	2,400	120

An expensive item was the perforated steel sheet for the floor of the box. A cheaper floor could be made of bamboo matting. The plastic sheet is not durable when exposed to the weather for long periods, and will probably have to be replaced each year. By using cheaper materials and by modifying the design the cost of the dryer can be halved.

Further Experimental Work

Another rice dryer similar in size and form to the one described here, and designed especially to facilitate experimental work, has been built on campus, and an extensive series of tests is in progress.

We have been able to observe the flow of air through the bed of paddy by natural convection, and to show that it is increased by the presence of the chimney. We have also found that drying takes place first at the bottom of the bed and later in the layers above in succession, except that grain at the top dries more quickly because it receives heat directly from sunlight passing through the plastic cover.

When these experiments have been completed and the results analysed our findings will be reported in a second paper.

Acknowledgements

We are indebted to the John F. Kennedy Foundation of Thailand for funds supporting solar energy research in the Asian Institute of Technology, without which this work could not have been initiated; to the International Development Research Centre, Canada for funds supporting a two year project for continued research and for introducing the dryer into the countryside; to the Rice Division, Department of Agriculture, Ministry of Agriculture and Cooperatives for the supply of paddy from the Klong Luang Rice Experimental Station and for the use of the milling test equipment during the preliminary studies in 1979; to AIT students Md. N. Boota, J. P. Kesari and Sompong Boonthumjinda who worked both on the site and in the laboratory; and to Khun Suwan Buaphut on whose farm the demonstration unit was constructed and used. We are also indebted to Dr. Gajendra Singh for valuable criticisms and suggestions relating to the work.

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Systems Approach to Solving Problems of Small Farms

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Abstract

Although 70% of Indias total land holdings are marginal and small yet areawise they account for only 21% of the total cultivated area. Green revolution, more or less, did not have perceptibel effect on these holdings. A mechanization programme which will allow these farmers to participate at par with big farmers in agricultural development programme is needed. In view of large number of failures in various mechanization programmes, a system approach is suggested to design and develop a mechanization programme for marginal and small farmers.

Introduction

India lives in villages. More than 75% of the population is either engaged in agriculture or dependent upon agriculture for their livelihood. No doubt India has made tremendous progress in many spheres in the last 30 years, but the rural masses have not greatly been affected by these developments. Furthermore, the upliftment of rural society has not been uniform throughout the country. Today the prospects look bright only for the States which had made some headway in agricultural development.

The country is committed to making concerted efforts in bringing about progress to be shared by all sections of society equitably, and all sections to have the opportunity to contribute their share for the development of the country. The present situation warrants that the main thrust of development programme should be directed to ameliorating the lot of 75% of the population, which lives in villages. They are mostly unorganized resulting in their inability to secure their rightful share of gains in development. Economic salvation, thus, lies in the development of rural India.

It is a lamentable truism that the green revolution, which swept the length and breadth of the country in the mid-sixties, could not embrace in its sweeping arms the marginal and small farmers. It remained confined to the rich farmers, and only filled the coffers of those who had the capacity to invest for new agricultural production technology, which was responsible for ushering in the green revolution. The new package of practices – high yielding varieties, fartilizer and irrigation could only be harnessed by the farmers having medium and large holdings. Green revolution, therefore, did not have perceptible effects on small and marginal farmers with holding sizes varying from 2 hectares and less.

If one were to observe this progress in agriculture in the background of the pattern of land holdings in the country, it will be seen that large segments of the rural population remaitned uninvolved in the dynamics of agricultural development.

According to the report on agricultural census of 1970 – 71, released in 1976, there were 70.5 millions operational holdings covering 162 million hectares which forms 49.4% of the total area of the country. Of this the net area under cultivation is 145 million hectares or 89% of the area under operational holdings. The average size of

*Presented at XVI Annual I.S.A.E. Convention held at I.I.T. Kharagpur, during December 18–20, 1978.

a holding is 2.3 hectares; the net area under cultivation being 2.06 hectares. Of the 70.5 million holdings, 35.7 million or 50.6% are of less than one hectare. These are classified as marginal holdings. Those between one and two hectares are termed as small holdings. In area, however, the two categories claim 9% and 11.9%, respectively, of the total cultivated area. A little over 24 million holdings are of the small and semi-medium categories of one to two hectares and two to four hectares, respectively. They account for 49 million hectares. Holdings of four hectares and more number 10.7 million or 15.2% of the total; their area is 98.2 million hectares. Of these, medium holdings, defined as between four and 10 hectares, number 7.9 million, covering 48.2 million hectares. The rest are large holdings of 10 hectares and more. Their number is 2.7 million or 3.9% of the total number of operational holdings, but areawise they represent the largest single segment of the agrarian structure covering 50 million hectares.

Though small and marginal holdings represent 70% of the total number of operational holdings their share in terms of cultivated area amounts to merely 21%. This indicates that majority of the farming population derives its sustenance from these land holdings. With the prevalent law of inheritance and the agrarian policy, there is no possibility in the foreseeable future that land holding sizes will stabilize at a certain level. On the other hand, there will be a continuous addition to the number of marginal and small farmers and this rise in number will further register an increase when the present agrarian reform policy is implemented and redistribution of surplus land among landless is completed.

It is, therefore, imperative that agricultural development programme should improve the economic status of the marginal and small farmers.

When we review the findings and ideas of some of the planners and economists, we find ourselves in a cross-fire of contradictions. Abercrombic and Johl as quoted by Faidley and Esmay[1] express differing views. K. C. Abercombic believes that most of the population is still in the rural areas and the agricultural labour force is still growing in absolute numbers, as in most of the developing countries, the agricultural and rural sectors are likely to have to bear much of the burden of employment. On the other hand, S. S. Johl says, "To the extent that total production and marketable surplus per unif of land increases, the increases in farm size should be acceptable, or reduction in farm size leading to decreased productivity, should not be acceptable, even if it (larger farms) may mean marginally lower employment". This implies that development programmes should be directed mainly towards larger farms and small farms should be left to he traditional technology.

Johl hypothesis fails completely in the light of results reported by Faidley and Esmay[1] who found that the small farmers with less than 0.4 hectare could compete successfully with large land holders in growing improved rice varieties, when mechanical power and irrigation were provided to them. This proves the fact that small farmers can participate in or directly benefit from agricultural development at par with big farmers.

Now the question remains how and what form of the development programme should be envisaged so that the entire rural society is involved in the dynamics of development. One may be tempted to suggest any one of the following programmes: Total mechanization, Selective mechanization, Cooperative mechanization, Govt. Custom-hire service, or private custom-hire service, etc.

But which alternative will suit a particular set of condition, and what shall be the effect of its concomitant fallouts, is complex to analyze.

Superficially developed opinions, experiences and generalizations and traditional piecemeal approach of developing and evaluating agricultural development programmes appear to be inadequate. An effective method is required which includes a systematic, concise, accurate and detailed analysis of the various factors and their interactions, and presents the problems in complete perspective. It should provide for iterative redesign of the development programme as changes occur in its operating environment.

System analysis has the potential for meeting these requirements and its application can greatly enhance the probability of success of development programme.

System Analysis

Following are the five cardinal components of system analysis[2,3,4]:

Feasibility Evaluation, Modelling, Implementation Design, Implementation, Operation.

Feasibility Evaluation

The need analysis is the first part of feasibility evaluation. Distinction between the real need of the society and expressed needs of an individual or a group is essential. Individials and groups should be so combined as to project the real need of the entire society. The second step in feasibility analysis is systems identification which consists of establishing alternative solutions or system concepts, which can meet the requirements of real needs. Input and output variables are identified. Total effect of controlled and environmental inputs is projected for analysis. After these two steps have been completed the problem is formulated in terms of hypotheses, which are possible explanations of the system behaviour. The criteria for evaluating system concepts are also delineated.

The final step starts with the generation of a broad specimen of system concepts. Each system concept is explored for physical, economic, financial and social and political feasibility.

Modelling

Model building is an extension and formalization of the statement of hypotheses. As an abstraction, simplification, or idealization of the system or event, the model helps to describe or in some way duplicate the real world. Models can not replace the real world; at best they reduce a complex system to managable proportions or serve to crystalize our thinking and perception.

Having observed the situation, specified the problem, formulated a hypotheses, and rendered the hypothesis specific by building a model, we then seek to evaluate the model. The testing or validating of a model can be done by making further observations and measurements of the system, or by experimentation. As new information is obtained, the model is checked against it to determine the correspondence between the model and real system. If subsequent observation can not be accounted for by the model, then it needs revision.

The model may initially be distinguished by their correspondence to the system being modelled, i.e., how nearly are they like the real thing. Physical models retain some of the entities of the system they represent. A physical model looks like its referent. Models that have been constructed from a set of physical objects not found in the real system are called physical analogues[6]. A mathematical model of a system consists of set of equations whose solutions explains or predicts changes in the state of the system. The use of mathematical models is a consequence of analytical effects to abstract and describe the real world. Mathematical models are highly abstract. Yet it is abstraction that makes mathematical models general, subject to manipulation and precise in terms of the information gained from their use. A computer model is simoly defined as a mathematical model expressed according to particular set of rules so that the model may be processed by a computer. The special purpose computer language, like DYNAMO, is sometimes used for processing the mathematical model.

Mathematical models may be subdivided into deterministic models and stochastic or probabilistic models.

Systems that deterministic models represent are devoid of uncertainty, and changes of state can be perfectly predicted. The way in which the system behaves can be evaluated according to measures of effectiveness, such as cost, profit, and time. Probabilistic models are those that include the representation of stochastic process of their results. Because uncertainity is more the rule than the exception, most of our models are probabilistic.

Simulation is another powerful technique in model building, Simulation problems are characterised by being mathematically intractable and having resisted solution by analytical methods. The problems usually involve many variables, many parameters, functions which are not well behaved mathematically, and random variables. Thus simulation is a technique of the last resort. Yet, much effort is now devoted to "computer simulation" because it is a technique that gives answers in spite of its difficulties, costs, and time required. Simulation is also described as a process of conducting experiments on a model instead of attempting the experiments with their real system. A general simulation procedure is depicted in Fig. 1.

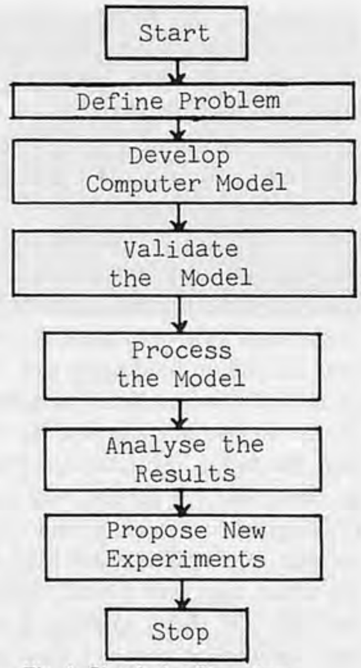

Fig. 1 Simulation Procedure

Analysis

After the system modelling and validation is completed, sensitivity analysis is required to determine which parameters and controllable inputs most significantly influence the system performance. The final step is system optimization. The optimization results in the specification of best combinations of system parameters and controllable inputs which satisfy the needs under the given constraints.

Implementation Design

It specifies the output of the system model. These results are successively reapplied to the various related subsystems. This involves the design and development of all organizational structures and supporting institutions, and determination of manpower and technical expertise needed for the entire system. Technical projects will fail if all subsystems have not been adequately developed.

Implementation

It provides physical existence to system design. Physical facilities and equipment are acquired, personal are hired and organizational structure established. The physical adequency of implementation design is tested and necessary corrections made.

Operation

It is the final phase of the system development and provides the real valid test of its adequacy. Modifications may be found necessary, but they should be few and slight. A system failure should rarely occur if the five phases of the system approach have been properly and vigorously followed.

Application of Systems Approach

The authors strongly believe that tillage operation is the area where mechanization can help the small farmers to successfully compete with large farmers in crop production. Tillage is traditionally done by a pair of bullocks. No land preparation is performed by a man with a spade. Small farmers are unable to own bullocks because some land is exclusively needed for fodder for them. A farm of about 1.5 hectare only can provide sufficient quantity of bhusa (chaff) or rice straw for a pair of bullocks. In the absence of bullocks these feeds can be utilized for rearing milch cattle – which will provide the farmer with extra income as well as badly needed nutrition. As the land holding size of the small farmer does not justify individual ownership of power unit, the authors suggest some kind of custom hiring.

Faidley and Esmay[1] report very encouraging result of the workings of a co-operative tractor station at Comilla, Bangladesh. They quoted that tractor hiring made it possible for farmers with less than 0.8 hectare (who did not own bullocks) to plant crop on 60% of their land, while those who owned bullocks could plant on only 49% of their land. In this case co-operative tractor mechanization thus proved one method by which mechanization could be made available to small farmers.

Therefore, it is established that custom hire either by government or private agency can bring the gains of mechanization within the reach of small farmers – provided that the government adopts a certain policy of selective subsidization programme for the benefit of small farmers. Most of the policies formulated to benefit the farmers hardly trickle down to small farmers. It is the big farmers who reap the maximum benefit of such policies. For example, if the government plans to reduce the taxes on tractors and other inputs, it will give relief of those farmers only who have the means to purchase these items. No benefit will, therefore, accrue to small farmers, because it is neither feasible nor profitable for him to invest in such machiner. But if a custom hire stations is operated by the government, cooperative or private enterprise, the government can frame a selective subsidization plan to benefit the station, and thus in turn the small farmers.

After having decided the need of small farmers – in this case tractor custom hire station, the major decision on which depend the success and failure of such service facility is their location and allocation. Here the objective is that these service stations should be located in such a way that they successfully meet the needs of farmers and also the machinery allotted to these centres have justifiable utilization. There had been large incidences of failure of tractor hiring stations mainly due to the lack of demand. Application of system analysis can avoid, to a great extent, such failure.

First thing in location of these centres should be the extensive survey of land holdings patterns, numbers of existing tractors, their remaining life and capacity, tractors booked for purchase, i.e. potential future buyers, future trend of tractors purchase. Cropping patterns, optimum periods for planting and harvesting, production operations needing mechanization, alternative land utilization plan, cropping intensification and diversification etc. These items are needed to be investigated, because they can throw light on potential demand. These interactions should be studied by modelling and then modern forecasting technique should be adopted to project the potential demand for a future period of 10 – 15 years – an acceptable life span of tractor and agricultural equipments.

A computer simulation model may be used to determine the optimum size of power units and matching equipments. This model can incorporate the influence of soil type, land size and geometry and equipment characteristics such as working width, turning radius and other relevant information.

The model can shed light on whether to go for one single high powered units or a number of small power units. Thus this model can be used to optimize farm operation cost as a function of land size, geometry and machine characteristics. Presently the tractor hiring stations are compelled to purchase one single high power unit (a tractor of 45 h.p. or more), where a number of small powered units could have been more successful. This sometimes results in failure of such stations.

A generalized computer simulation model as used by Faidly and Esmay[5] can be designed to simulate the operation of tractor hiring station such as shown in Fig. 2. This type of model can interconnect the amount and distribution of demand performed and delayed, randomly occuring breakdowns and repair times and costs, replacement policy with consideration of reliability and operating cost. This type of model comes handy when one wants to evaluate the effects of change of management policy without really changing the system in real world. Thus, this type of model can determine the optimum numbers of tractors and equipment required to provide timely and economic service to farmers.

Simulation model may be used to design optimal repair facility and optimal spare parts inventory also.

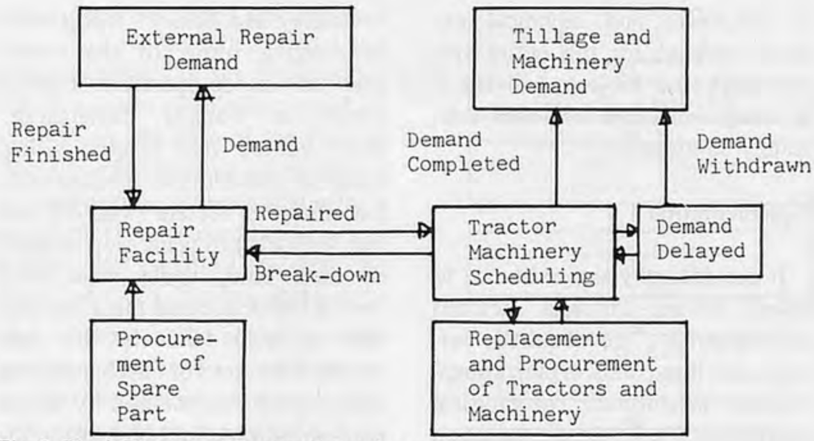

Fig. 2 Block Diagram of Tractor Operation

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A Low Cost Solar Rice Dryer

(Continued from page 77)

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Bruce H. Anderson Receives Kishida International Award

Bruce H. Anderson, executive director, Consortium for International Development (CID), Utah State University, Logan, is the 1979 recipient of the Kishida International Award which was presented by the American Society of Agricultural Engineers (ASAE) during its summer meeting, June 24–27, at the University of Manitoba, Winnipeg.

ASAE is a non-profit, technical, scientific and educational society committed to improving agriculture through the application of engineering principles. Headquartered in St. Joseph, Michigan, the Society has 7,900 full members and 2,000 student members in 50 states and 90 foreign countries.

The Kishida International Award recognizes outstanding contributions to engineering, education, research, or other programs that have improved food production, living conditions, and/or education for people living outside the United States. It is sponsored by Shin-Norinsha Co. Ltd., Tokyo, Japan, in honor of Yoshikuni Kishida, founder of the company.

Anderson has an international reputation for his work, research, program development and administration of agriculture-related projects, particularly irrigation and drainage. He spent 9 years in Iran where he developed a research and training farm which is now the site of the Pahlavi University, Shiraz, Iran. Between 1964 and 1973 he served in the Inter-American Center for Integral Development of Land and Water Resources in Merida, Venezuela, where he developed a personnel training program in land water resource development for all South and Central Amrican countries and later supervised cooperative research programs in Chile, Ecuador, El Salvador, Brazil and Colombia.

Alternative Transportation Fuels Data Library Set up by Department of Energy

The U.S. Department of energy (DOE) Office of Transportation Programs recently announced the creation of an Alternative Fuels Data Bank to provide a library for technical information on alternative fuels for transportation. The data bank is currently set up to handle information requests primarily for alcohol fuels. Information on other alternative fuels such as hydrogen, synthetic fuels from shale, coal, and biomass is available to a lesser extent (see chart).

The data bank is located at DOE's Bartlesville (Oklahoma) Energy Technology Center. It will collect, catalogue, and standardize information on alternative fuels available from experts working in the alternative fuels field. The data in bank is divided into published technical information, research information in development stages, and topical information listed by subject.

Those interested in using the data bank must have access to a computer terminal with an acoustical coupler to be used with commercial telephone lines. Each user will need an individually assigned system entry code to use the computer service. Except for Monday from 5:30 p.m. to 9:30 p.m. (central time), the link to the computer will be available 24 hours a day, 7 days a week.

Systems access code and other information is available by contacting Ken Stamper, at the Bartlesville Center, (918) 336-2400, extension 258. His FTS number is 735-4258.

Current Status of Alternative Fuels: Data Bank Information System

Alternative Fuels	Subject Area			
	Production or Processing	Physical Properties	Utilization	Economics of Utilization
Alcohols	Limited Coverage	Limited Coverage	Comprehensive Coverage	Limited Coverage
Hydrogen	"	Little info available	"	"
Synthetic fuels from shale	"	"	"	"
Synthetic fuels from coal	"	"	"	"
Synthetic fuels from biomass	"	"	"	"

Note: The primary focus of the data base activities has been on the subject area of utilization; decreasing emphasis is placed on the area of "economics of utilization," "physical properties," and "production or processing."

NEW PRODUCTS

INTEC 78 Tractor

The new INTEC 78 Tractor provides 4 speeds from one to 12 KM. per hour while retaining simplicity in contruction and maintenance. The large 70 cm. outside diameter tires (6.7 x 15) provide 27 cm. of clearance. With 30 kg. of liquid added to each wheel, the tractor weighs 180 kg. Wheel weights may also be added. A 7 H.P. Briggs and Stratton gasoline engine or a 7 H.P. Lombardini diesel gives dependable power.

Conventional tillage tools are the 19 cm. moldboard plow, 1 meter disk harrow, planter with fertilizer attachment, toolbar type cultivator and ridger, centrifugal pump, propellor pump, 3 KW generator, rotavator wheels, and .5 M^3 cart.

Minimum tillage tools have been produced to reduce fuel costs and equipment investment. A 2 row rotary injection planter will plant in mulch with much less penetration weight than disk opener units. These planter units may replace the tractor wheels or may be pulled behind the tractor. A controlled droplet application (C.D.A.) sprayer system can be mounted on the trailer to provide efficient herbicide distribution with only 10 liters water/hectare. The International Institute of Tropical Agricultural in Nigeria has shown this type of zero tillage system at this power level suitable to farm up to 30 HA of rainfed agriculture.

(Intec Dowding Tool Products, Inc.: 8950 Narrow Lake Road, Springport, Michigan 49284, U.S.A.)

Iseki T6500 Tractor

Water-cooled four-cylinder diesel engine is mounted, which was newly developed exclusively for medium-size tractor. The tractor is featured in its "Competence" for heavy work-loads as well as long-time operations.

The engine is really efficient with larger capacity of exhaust.

The tractor adopts the power steering system, which enables the driver to obtain sure steering. Most suitable speed can be selected from among 20-speed forward and 4-speed reverse in accordance with the nature of work. Creep speed is also available. Various works of paddy field, upland field and dairying can be completed with high efficiency.

[Specifications]

Dimentions: 3,630 x 1,750 x 2,420 mm (end of muffler: L x W x H), Engine output: 65 ps, Exhaust: 3,595 cc, P.T.O.: Independent 2-step, Lifting gear: With draft control system: with position control system.

(Iseki & Co., Ltd.: 3 Kioi-cho, Chiyoda-ku, Tokyo 102, Japan)

Iseki TS Series Tractors

Choose one of these TS series tractors (TS 3510 – 35 ps/2,400 rpm, TS 2810 – 28 ps/2,600 rpm, TS 2510 – 25 ps/2,600 rpm) to meet your needs, keep your operating efficiency up and costs down.

All three machines share the same basic concept although they have different size engines which determine their suitability for tasks to be performed. Pay only for the power you need, not for more than you can use. Many of the engine component parts are interchangeable as all three units are made by ISUZU, a famous diesel engine maker in Japan.

The engines are distinguished for their performance, economy and durability. These water-cooled diesels are especially suitable for day-long operation. They have plenty of torque in all speed ranges, are quieter and vibrate less than some others, which means operator fatigue will be reduced.

A pre-heated glow plug enables easy starts even in cold weather and the extra large capacity radiator helps avoid over-heating problems in hot climates.

The TS2810 and TS2510 models have nine forward speeds and three reverse speeds. The extra power put out by the TS3510 means that eight forward and two reverse speeds will do the job.

The 4-speed PTO handles most needs.

(Iseki & Co., Ltd.: 3, Kioi-cho, Chiyoda-ku, Tokyo, 102 Japan)

Sasaki CW-90 Compost Mixer (Medium type, conveyor system)

1) Application: Renewal Compost
2) Features: a. Compact size and good maneuverability; b. Capable of any type of mixing with ease. c. Uniform mixing is attained. d. Drum type rotary mixer allows smooth flow of straw; e. Easy control of water sprinkiling. and f. Towing by any tractor for travel.
3) Specifications: Size (L.W.H.)

4700 x 1400 x 2700mm, Weight 700kg, Working Width 900mm, Mixing efficiency 3–10 tons/hr, Towing type

(Sasaki Noki Co., Ltd.: 259-1, Satonosawa, Towada, Aomori 034, Japan)

Sasaki SM-100 Manure Spreader of Tractors for 15–35ps

1) Application: Spreading manure carrying straw, fertilizer, harvest, forage, etc.
2) Features: a. Easy control of fine or dense broadcasting; b. FRP-made ground; b. Conveyor has five speeds to meet different conditions; c. Low-section high tire is equipped for easy operation even on soft ground; d. Tines help uniform manure spreading; e. Shear-pin breaks if excess force acts on beater conveyor; and f. Can be used as trailer.
3) Specifications: Size (L.W.H.) 4000 x 1660 x 1340 mm, Weight 590kg, Working width 2,000–2,500mm, Efficiency 20–32 are/hr, Payload 1000kg, Speed 3–5 km/hr, Drawn model

(Sasaki Noki Co., Ltd.: 259-1, Satonosawa, Towada, Aomori 034, Japan)

Sasaki GF-260 Flicker Type Broadcaster over 20 ps

1) Application: Broadcasting fertilizer (powder, pellet) or seed.
2) Features: a. Easy control of fine or dense broadcasting; b. FRP-made hopper has long life. c. Reciprocating mechanism assures uniform broadcasting; d. Important parts are made of stainless steel; and e. Hopper is located relatively low to facilitate easy delivery of fertilizer.
3) Specifications: Size (L.W.H.) 1163 x 1284 x 979 mm, Weight 80kg, Working width 8,000–10,000mm, Hopper capacity 260 litres, Speed 4–8 km/hr, Mounted through 3-point link.

(Sasaki Noki Co., Ltd.: 259-1, Satonosawa, Towada, Aomori 034, Japan) ■■

NEW PUBLICATIONS

Mechanization of Indian Farming
(India)

The role of mechanization in Indian agriculture has become a controversial issue, mainly because of the staggering unemployment in India. However, there has been a need to make an objective study of this problem considering the total impact of mechanization. The author has made a deep study of this problem. In some parts of India, tractors and pumps are used in larger numbers but most of the technical appliances like mowers, threshers, combines are absent. Thus, there is only partial and no full mechanization.

This book analyses the micro-economic, social and other effects of the first phase of technological change. Increased agricultural production can be achieved only if modern technology is applied. If old techniques are maintained, labor productivity cannot be increased.

Size: 22.3cm x 14.5cm, xii + 132 pages, with hard cover published by POPULAR PRAKASHAN PRIVATE LTD. 35c Tardeo Road, Bombay 400 034, India.

Food and Nutrition Bulletin
(Quarterly, US$10.00: one-year subscription)

Protein-Energy Requirements Under Conditions Previling in Developing Countries
(US$3.00)
(Japan)

These publications are a result of the research work done by the World Hunger Programme, one of the three main programme areas, of the United Nations University.

A major component of the World Hunger Programme is national food and nutrition policy – a subject widely ignored in the past. Another project deals with staggering losses of food (up to 40 percent in some developing countries) after harvest.

A further project is concerned with developing comprehensive information on human nutritional requirements in tropical areas of the developing world, for which such information has been severely lacking. In all this work, the World Hunger Programme is strengthening the efforts of other organizations concerned with increased food production and better nutrition.

The Food and Nutrition Bulletin, and its supplement, Protein-Energy Requirements under Conditions Prevailing in Developing Countries, are indispensable source books for nutritionists, food planners, food economists, agricultural specialists and all those concerned with problems of food and nutrition planning.

A valuable source of information in an area in which there has been only little, highly inadequate research until now.

Orders should specify the title of the publication and be accompanied by a cheque in the appropriate amount in the name of the United Nations University and be addressed to:

Academic Services, United Nations University
29th Floor, Toho Seimei Building, 15-1 Shibuya, 2-chome, Shibuya-ku, Tokyo 150, Japan

Post-Harvest Rice Systems
(Rep. of Korea)

This is the final report of the research project "Post-harvest Rice Systems (Korea)" conducted with financial assistance from the International Development Research Center in Ottawa, Canada.

The two primary objectives of the research project were to identify problems posed by the existing rice post-harvest technology with special reference to Korean-version of high yielding rice varieties, and to determine appropriate technologies with a view to improving the existing system.

The authors have rendered all possible efforts to identify problem areas related to the post-production technology in the Rep. of Korea. For the two-year period of the project, extensive field surveys and experimental works were conducted. The major results of the research study are presented in four separate papers, namely:

(1) An Analysis of the Operational Characteristics of Traditional Paddy Harvesting Systems;
(2) An Evaluation of Rice Post-harvest Systems in Terms of Grain Losses and Maximum Recoveries;
(3) Effects of Thresher Drum-speed on the Quality of Milled Rice; and
(4) Profiles of Rice Mills in the Rep. of Korea

Size: 25.5cm x 18.2cm, viii + 194 pages, with soft cover.

Published by the College of Agriculture, Seoul National University, Suwon, Rep. of Korea.

Research Highlights for 1978
(Nigeria)

This report highlights some of the most significant research results from the more than 1,000 experiments conducted by the International Institute of Tropical Agriculture (IITA) in 1978. The objective of these experiments is to find solutions to the constraints on increased production at the farm level and, in particular, for the small farmer in the tropics who has little access to purchased inputs. Some of the information collected provide can be used immediately to improve food crop production and thus the living standards of people in the humid and sub-humid tropics. Other data help build on the basic knowledge required for longer term solutions of the problem.

This report is designed for those who would prefer an overview of areas of work where significant achievements were achieved during 1978. The full comprehensive activities of the Institute are published in the IITA's Annual Report.

Size: 22cm x 17.2cm, 64 pages, with paper cover.

Published by the International Institute of Tropical Agriculture, Oyo Road, PMB 5320, Ibadan, Nigeria.

– 1978 Edition –
Asian Development Bank Annual Report
(Philippines)

This Report begins with following comment:

The Year 1978 was marked by a substancial expansion in the Asian Development Bank's lending and technical assistance activities. For the first time, the Bank's annual lending exceeded $1,000 million. Technical assistance approvals also recorded a sharp increase to $11.1 million.

The Bank broke new ground in a number of fields: it made its first loans in the health sector and also its first program loan. It made its first public offering of an external yen bond issue on international capital markets. The year saw the successful conclusion of efforts to replenish the Asian Development Fund (ADF), the Bank's soft loan window, on a larger and longer-term basis than in the past. The Bank also took a number of steps to strengthen its internal structure in an effort to respond more effectively to the region's development needs. As usual financial statements and statistics are major constituent of this report.

This Report measures 26.8cm x 20.9cm, with soft cover. Published by the Asian Development Bank, P.O. Box 789, Manila, Philippines

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– 1979 Edition –
Agricultural Engineer's Yearbook
(Philippines)

This Yearbook is addressed primarily to all members of the Philippine Society of Agricultural Engineers (PSAE). These members may just be starting their formal study of agricultural engineering or those who, by the very nature of their endeavors require decisive decisions which hopefully this Yearbook may be of valuable reference. In the selection and presentation of materials, the staff kept in mind the needs of undergraduate and graduate students and teachers of agricultural engineering, including government and private agricultural engineers and our colleagues in other disciplines of engineering.

Size: 28.8cm x 22.3cm, 127 page, with hard cover.

Published by the Philippine Society of Agricultural Engineers, Manila, Philippines.

A Report on Rice-Postproduction Technology Project, 1978
(Philippines)

During the past decade there have been repeated attempts to foster interest in the problems associated with postproduction systems for foodgrains in the developing nations. A few studies have been prophetic in accurately portraying the issues that have accompanied significant increases in foodgrain output. Many have focused on the problems of grain losses and the potential embodied in reducing these to increase grain output and grain quality. Grain loss is a contemporary item in the work plans of the Food and Agriculture Organization, the World Food Council and several major donor agencies.

There exists a general assumption supported by these groups that 1) losses and unnecessarily high; 2) the prescription is the introduction of improved management and technology; and 3) farmers and processors cannot or will not take action to eliminate those losses without external assistance. The lack of any notable success in reducing losses (or evidence of reductions) in most countries is generally ascribed to a lack of information and suitable research methodologies with which to describe the nature, magnitude, location and causes of losses in traditional postproduction systems.

The present study (Bicol Region, Southern Luzon) focuses largely on an examination of the technical aspects of postproduction operations, including the interdependencies that exist between components of each system. There has also been an attempt to examine the economic and institutional factors that condition the selection of a particular patterns of technology. While many questions remain unanswered, the insights suggested by the study will hopefully prove useful in formulating guidelines governing planning and development of improved post-production programs.

Size: 27.7cm x 24.4cm, x – 214 pages.

Published by the International Rice Research Institute.
P.O. Box 933, Manila, Philippines

1977 IRRI Annual Report
(Philippines)

Topics and sub-topics in the Machinery Development and Testing Section of this report cover the following:

Summary

Machinery Design

- 6- to 8-hp tiller with steering clutches;
- Rotary tiller attachment for the 6- to 8-hp tiller;
- Multicrop upland seeder;
- Rice transplanter;
- Plow-sole granular-chemical applicator;
- Portable axial-flow thresher;
- Harvester attachment for power tiller;
- Vertical-bin batch dryer;
- Steam and producer gas generation; and Engelberg rice mill project

Mechanization Research

- Compacted soil studies;
- Power tiller upland tillage tests;
- Field tests of three transplanting systems; and
- Testing and evaluation

Mechanization Systems

- Market for farm machinery; and
- Mechanization in upland cropping systems

Industrial Extension Program

Size: 25.2cm x 17.7cm, xxii + 548 pages, with soft cover.

Published by the International Rice Research Institute, P.O. Box 933, Manila, Philippines

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Effects of Pneumatic Tires on Soil Compaction and Infiltration Rate
(Pakistan)

Throughout the world, concentration is being focussed on the use of tractor as a power source on the farm. Different types of implements have been designed to use along-with the tractor for plowing and seed-bed preparation. One of the main goals of plowing and seed-bed preparation is to increase the infiltration rate by reducing the soil compaction in order to provide necessary conditions for successful seed germination and for the better development of plant roots. Infiltration rate is the time rate at which water passes into the soil, and soil compaction generally expressed in terms of dry density, is the weight of the solid per cubic foot of soil in bulk.

The weight of a tractor along-with a cultivator is about 5800 lbs., which acts upon only about 5 sq. ft. area of the soil underneath the tractor tires. After plowing apparently the soil particles looks quite loose, but in fact the dry density and infiltration rate of the loose soil in-between and on the tire tracks is quite different, depending upon the number of plowings, assuming all the other factors remain constant and this difference results in an uneven growth of crop which ultimately affects the total yield.

A simple experiment was conducted in this regard in Pakistan on clay loam soil. In the experiment, a tractor MF 165 along-with a cultivator was used for plowing. An auger tube with a steel hammer was used to take soil samples, and infiltrometers 1 ft. in diameter and with a height of 1.5 ft. were used for infiltration rate determination. Soil moisture contents were determined using Speedi Moisture Tester and as well as by oven drying method. The results evaluated for soil compaction and infiltration rate are well representative of the hard pan created on the subsurface of the soil due to the weight of tractor which could offer a remarkable resistance to plant roots penetration, and as well as to intake rate of water. Also, the results on the interrelationship between infiltration rate on and in-between the tire tracks and the respective dry density parameters including number of plowings have been presented. In short, this study provides some specific data and an alarming information about harmful effects which can occur as a result of using a tractor with pneumatic tires for plowing and speed-bed preparation in the field.

by **Muhammad Boota** (Asst. Agril. Engineer, Agril, Engg. Dept., Multan, Pakistan), **Syed Iqubal Ahmad** (Research Fellow, Univ. of Illinois, USA) **M. Muhboob Alam** (Jr. Agril. Engineer Wapda, Lahore, Pakistan)

Handbook of Livestock Equipment
– Second Edition –
(U.S.A.)

The aim of this book is to bring together most of the information known about equipment and facilities that have to do with efficient livestock production. Safety and labor-saving equipment have been highlighted throughout the volume, as well as the use of local economical resource material.

In some instances more than one set of plans are shown for a given item. This is done purposely so that producers, teachers, or students may have a choice that fits their individual preference, available materials, or ranch conditions. With a few exceptions, enough detail is shown and enough sizes are indicated so that anyone who is handy with tools and who has some knowledge of construction can build the equipment directly from drawings in the book.

Livestock producers, teachers, extension workers or county agents, students, and 4H and FFA members will find a wealth of ideas in this publication needed to put the science of livestock production into action.

Size: 27.5cm × 20.5cm, x + 371 pages, with hard cover.

Published by the Interstate Printers & Publisher, Inc. Danville, Illinois, U.S.A.

Postharvest Food Losses in Developing Countries

(U.S.A)

As the world's population grows, increasing the food supply becomes an ever-more-urgent priority. One vital- and neglected-step toward this end is to reduce the food losses that occur between harvest and consumption.

Reliable studies indicate that postharvest losses of major food commodities in developing countries are enormous, in the range, conservatively, of tens of millions of tonnes per year and valued at billions of dollars. Programs for reducing these losses and evaluations of program effectiveness must be based on reasonable estimates of their magnitude. Yet it is very difficult to estimate postharvest food losses with precision. Partly, this is due to their inherent variability. But it is also a result of many cultural and economic factors that frustrate the smooth, efficient flow of food through the postharvest system from producer to consumer.

Useful loss estimates are possible, however, as is improvement in food conservation. This study is devoted to assessing both the potential of food loss reduction efforts and their limitations. It summarizes existing work and information about losses of the major food crops and fish; discusses some of the economic and social factors involved; identifies major areas of need; and suggests various policy and program options for developing countries and technical assistance agencies.

Size: 22.8cm x 15cm, viii + 206 pages, with soft cover.

Published by the National Research Council, 2101 Constitution Avenue Washington, D.C., U.S.A.

Practical Farm Building:
A Text and Handbook
– Second Edition –

(U.S.A.)

The average farm building is small and, from a large contractor's or a consulting engineer's viewpoint; quite insignificant; not justifying the time spent to design it. Only for the last 15 years have there been contractors specializing in farm structures.

After many years of interpreting design data for non-engineers, it became apparent that rules of thumb and approximations used in practical designs would be useful in teaching non-engineers.

The same type of information can also be used by county agricultural agents and vocational education teachers who advise farmers on farm building problems.

This book is intended for both a text for teaching and a reference providing on-the-job advice on farm building for non-engineers.

Size: 28cm x 21cm, xiv + 277 pages, with soft cover.

Published by the Interstate Printers & Publishers, Inc. Danville, Illinois 61832, U.S.A. ■■

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Research Officer (Soils Scientist), Research Division, Department of Agriculture, Koronivia Research Station, January 1969–December 1972.

A NOTE TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles for publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

Priority in the selection of articles for publication is given to those that —

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100 word-abstract, preferably preceding the main body of the article ;
f. are typewritten, double-spaced, about 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. The AMA does not pay for articles published. However, the writer(s) is given 10 free copies of the AMA issue wherein the article appears, including 50 off-prints of the article so published.

Procedure

a. Articles for publication (original and one copy) must be sent to AMA through the Cooperating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organzation, nationality and complete mailing address.

Format/Style Guidance

a. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
b. The pages must be numbered (Arabic numeral) successively at the top center. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e. g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top, center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e. g., "Figure 1. View of the Farm Buildings".
c. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
d. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
e. Express measurements in the metric system and crop yields in metric tons per hectare (mt/ha) and smaller units in kilogram or gram (kg/plot or g/row).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e. g., 45.5kg/ha instead of 45.4762kg/ha.
i. When numbers must start a sentence, such numbers must be written in words, e. g., Forty-five workers . . . , or Five tractors . . ." instead of 45 workers . . , or, 5 tractors.

BACK ISSUES

(Vol. 9 No. 1, 1978~)

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AGRICULTURAL MECHANIZATION IN ASTA (Vol 10 no. 2, Spring, 1979)

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AGRICULTURAL MECHANIZATION IN ASIA (Vol. 10 no. 3, Summer, 1979)

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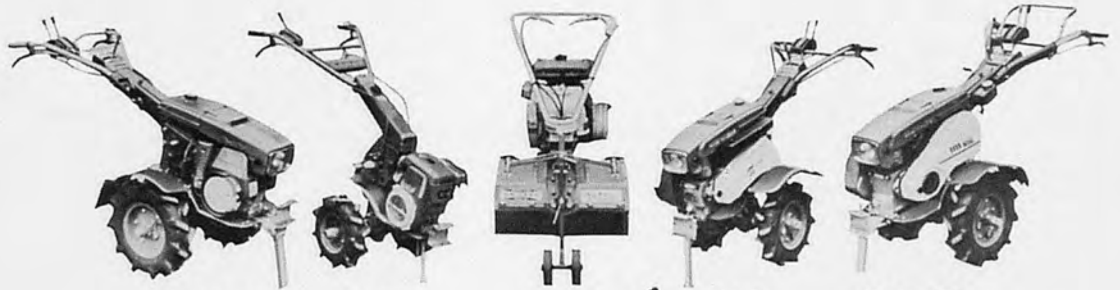
AGRICULTURAL MECHANIZATION IN ASIA (Vol. 10 no. 4, Autumn, 1979)

CULTURE ALL OVER THE WORLD



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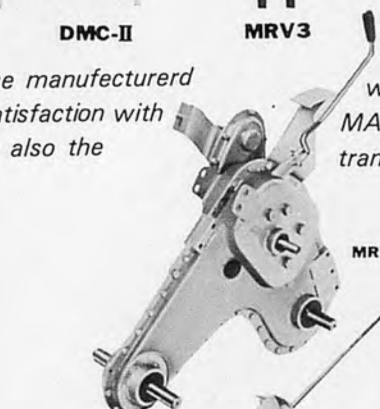

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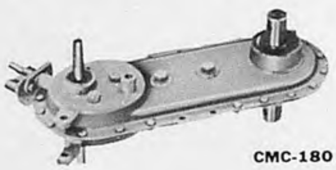

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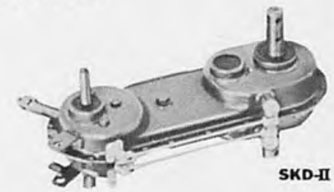

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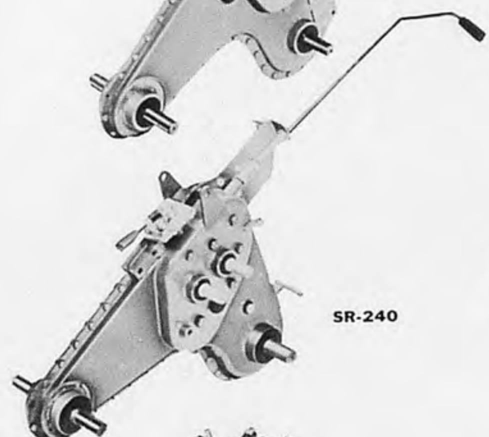

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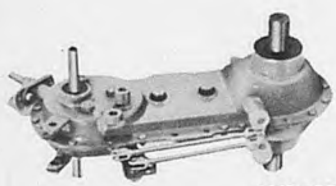

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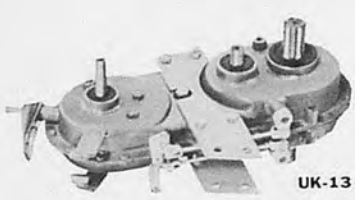
HMD-250



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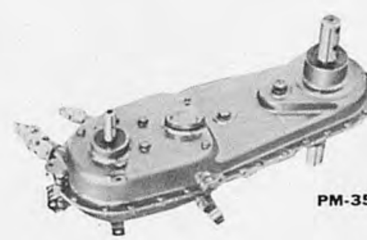

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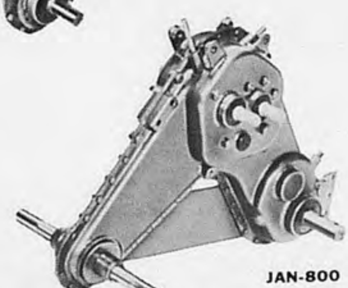

JAN-800

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