FARM MECHANIZATION IN RICE CULTIVATION

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Abstract

The scarcity of manual labour and the drudgery require alternate sources of power to carry out different farming operations. Machines and tools could easily be found to replace the labour bringing other advantages such as timely cultivation, increased quality and perhaps less production cost. But, a country like Sri Lanka has several restrictions to introduce machinery due to socio-economic reasons. The agricultural mechanization process, therefore, has taken a selective form to ensure a balance between available labour and the need of machines for timely operations. Within the influence of free trade economy the subsistence level farming may gradually change into commercial level requiring labour saving machinery. It also would be essential in keeping rural youth intact with paddy farming. Mechanization could play a complementary role in improving seeds and effective application of fertilizer, which are key requirements for increased yield. The production of rice in particular is the activity mechanized most. In this context almost every farming operation, from land preparation up to rice processing has been mechanized at different levels. In the land preparation, tractors have taken over nearly 87% of the total extent. Recent studies indicate that riding type two-wheel tractor has advantages over the others in respect of capacity and fuel efficiency. In order to complete the land preparation within two weeks, at the beginning of each season, the additional amount of power needed in the field would be 556,920 hp. The plant establishment methods, whether broadcast, row-seeded or transplanted, need additional attention in order to ensure the subsequent operations become conducive for mechanization. Efficient use and application of fertilizer, invulnerability for lodging *etc.* depends totally or partially on the method of establishment of crops. Breeding programs would have to be undertaken to develop rice varieties resistive for lodging. The weeding operation could be mechanized only if the crop is established in rows. Wide row spaces facilitate easy application of mechanical weeding with higher efficiency. When the reapers and combine harvesters are used, the crops established in rows provide other advantages, such as increased work capacity and decreased field losses. The number of sprayers available in the field is insufficient, in an emergency, and at least 300,000 more sprayers must be made available at the hands of farmers. The success of the attempts taken to introduce two-wheel tractor coupled reapers and self-propelled combine harvesters was dependent on the condition of the crop at the harvesting stage and the cost of the machines. A small-scale combine harvester coupled to the existing two-wheel tractor would be one of appropriate solutions. Axial flow threshers powered by two-wheel tractors or separate engines have proved that they are superior when compared to the other traditional methods in respect of reduced losses and increased quality. The straw presently go in a waste also could be utilized if the portability characteristic of these machines is made use of in the field. Encouraging the design and development of appropriate machines, increasing the local manufacturing capability and increasing financial resources for the farmers to purchase the machinery are some of the solutions to overcome these problems.

INTRODUCTION

The need of machinery for rice cultivation arises when seeking solutions for the problems like drudgery, high production cost, low quality, low cropping intensity and above all the labour scarcity. Various tools in appropriate forms had been used in the history of cultivation of rice. From time to time the need has been changing and today the major concern is to lower the cost of production, increase the quality and solve the problem of scarcity of labour. In a survey conducted jointly by FMRC and the University of Peradeniya, it was found that 84% of the farmers gave top priority in the process of mechanization for cultivation of rice. This same survey also revealed that only 2% of the farmers accept that their farming operations are sufficiently mechanized. During the past, efforts had been made to mechanize various farming operations but the achievements are not satisfactory. The task of introducing machines to our farmers had not been easy due to various reasons. Since the importance of machinery has now been realized, immediate but well planned, mechanization programmes must be launched in order to achieve sustainability in rice production. In this context, the labour intensive and time-consuming operations should be clearly identified and at the same time increasing the quality of products also should not be neglected.

OBJECTIVES

The objective of this paper is to analyze the present status of mechanization in different farming operations in rice cultivation and then identify suitable measures capable of addressing shortcomings and problems.

METHODOLOGY

For the analyses of mechanization status, suitability of different machines for different operations, cost of the machines, capacities, fuel consumptions, locally manufacturing possibilities etc. have been considered. The required data were obtained from the experiences of FMRC, FMTC and University of Peradeniya, literature from DOA, experiences from other similar countries and research papers from various authors and institutions. Selecting and suggesting appropriate solutions for respective problems was done mainly after making comparative type of analyses. Preference also has been given for the mechanization processes involving cost effective and competitive type of local manufacture.

Status of mechanization with respect to different farming operations

A total of 899,000 ha of paddy fields, islsand wide, need some form of power for operations such as land preparation, plant establishment, weeding, irrigation, crop protection, harvesting, threshing, paddy cleaning and storage. The following are the available units of machinery for paddy cultivation in Sri Lanka.

Machinery	*No. of units*
Two-wheel tractors (6 – 12 hp)	55,000
Four-wheel tractors	15,000
Ploughs	
(a) Mould Board (for two-wheeler)	18,000
(b) Mould Board (for animal)	75,000
(c) Rotary ploughs (for two-wheeler)	54,000
(d) Nine tine tillers	10,000
Weeders	4,500
Sprayers	105,000
Paddy reapers	2,500
Paddy threshers	30,390
Winnowing fans	20,000
Transplanters	825

(Source: FMRC 1999)

Let us consider the level of mechanization in each of the above operations.

Operation	*Level of mechanization*	*Remark*
Land preparation	87%	Final leveling is done by manual or animal power
Transplanting	02%	Includes row seeding
Weeding	02%	This is possible only for the crops established in rows
Chemical spraying	100%	
Reaping	08%	Two-wheel tractor coupled vertical reaper
Threshing	45%	Excluding tractor treading
Winnowing	82%	Winnowing fans coupled to two or four wheel tractors
Paddy cleaning	75%	Final cleaning is done when preparing for seeds and for milling

(Source: RNAM & FMRC)

Land preparation

Land preparation is generally done using two wheel tractors, four wheel tractors, animal and manual power. This operation involving primary tillage, secondary tillage, puddling and leveling are usually performed almost simultaneously at the beginning of the two seasons island wide. That means the available power would have to be mobilized in order to complete the operation on time. It is said that nearly 50% of the available land is unable to be cultivated during the Yala for scarcity of water resulted due to late land preparation in both seasons. This delay is mainly due to the lack of farm power for land preparation. The average power requirement per hectare per day in different steps in land preparation is given below;

Primary tillage	15 hp/ha/day
Secondary tillage	10 hp/ha/day
Puddling & leveling	10hp/ha/day

In accordance with the present availability of tractors and animal population, the total power available in the country is 1,113,840 hp (440,000 hp from two wheel tractors, 525,000 hp from four wheel tractors and 148,840 hp from animal and manual). This is equivalent to 1.23 hp/ha and percentage wise nearly 87% of the land is prepared by tractor and 13% is by animal and manual power.

With the present available power, time taken for the three sub operations in land preparation could be calculated as:

Duration for primary tillage (15/1.23)	12.20 days
Duration for secondary tillage (10/1.23)	8.13 days
Puddling and leveling (10/1.23)	8.13 days
Total	28.46 days

In addition to this, the work involved in clearing bunds and establishment of crop take at least 8 days to 30 days depending on the method followed for seeding and transplanting. If the duration taken for land preparation were to be shortened by two weeks the additional amount of power needed in the farm would be 556,920 hp.

The statistical data shows that there is nearly 3000 two wheel and four-wheel tractors are annually added to the tractor pool in this country and it is worthwhile to consider the best suitable tractor type with respect to capacity, fuel consumption and prize. The FMRC test data reveals the characteristics pertaining to different engine sizes of tractors as shown in the table 1.

Table 1. Relationship between capacity and fuel consumption of different tractors against their horsepower (Source: FMRC 2000).

Tractor power hp	*Fuel consumption l/h*	*Capacity ha/ 08 h day*	*Capacity ha/ l of fuel*	*Remarks*
07	1.0	0.40	0.05	Walking type two-wheel tractor
12	1.4	1.00	0.09	Riding type two-wheel tractor
35	4.5	1.40	0.04	Four-wheel tractor

In accordance with the table 3, the 12 hp riding type two-wheel tractor gives the maximum work out put per liter of fuel consumption. Another important matter to be considered is that the smaller horsepower tractors do not last as long as the larger ones. But as the power increases the cost of the tractors also increases and the cost per unit power decreases. Therefore, 12hp two-wheel tractors could be suggested as more suitable for land preparation. Since this operation is toilsome and difficult to be replaced, no attempt was made to compare the performance of manual or animal power with tractor power.

Crop establishment

More than 90% of the paddy fields are broadcast shown and a competitive yield is obtained using the recommended quantity of fertilizer and herbicide. This is the fastest, simplest and cheapest method when compared to row seeding and transplanting (Table 2). Although there is no significant yield difference in all three methods, experience indicate that row seeding and transplanting makes the subsequent operations conducive for mechanizing labour and time-consuming operations such as harvesting. At the last *maha* the scarcity of labour for harvesting was reported from many parts of the island and an instant demand for combine harvesters was indicated from large-scale paddy growing areas. Certain organizations had imported and supplied Japanese and Korean reconditioned combine harvesters. But, only 60% of the paddy crop was found to be un-lodged to facilitate application of them (FMRC 2000). Crop establishment system in Korea is gradually changing from row transplanting to row seeding since 1993, mainly because of excessive cost. However, crop lodging is their major concern and emphasis was solicited for developing lodging resistant varieties. In addition to developing invulnerable paddy varieties for lodging, transplanting could be encouraged as it was proved to be less susceptible for lodging. We also have experienced during the recent past that the row seeded and transplanted crops could withstand pest attacks like brown plant hopper.

Table 2. Cost-benefit comparison of different crop establishment methods.

Method	*Rs/ha*	*Advantages*	*Disadvantages*
Broadcasting	300	Quick, Easy and Cheap	Need less seeds; Bird & rain damages, Chemical weeding only, easy to lodge
Row seeding	600	Need less seeds, Easy to operate weeding, fertilizing & harvesting machines,	Bird & rain damages,
Random transplanting	5300	Need less seeds; Control of weed by water	
Row transplanting	1600	Need more seeds; Easy to operate weeding, fertilizing & harvesting machines, less lodging	

The facts thus mentioned are, therefore, encouraging to conduct further research to develop crops that could withstand lodging until it is reaped. In addition, the mechanization institutions should be allowed to introduce appropriate type of seeding and transplanting machines.

Plant protection

Weed, pest and disease control is done using chemical sprayers. This technique is 100% mechanized in the case of rice cultivation. The over-head knapsack type stainless steel hand sprayers are the most popular. Nearly 105,000 hand sprayers are being used covering an area of nearly 9 ha per sprayer. The average capacity of such a sprayer is about 1 ha/day (FMRC). This data shows that there is a deficiency of sprayers in the field. In general, for high demand application of chemicals, at least one sprayer is needed to cover up an area of 2 ha. Therefore, to be in the safe side, nearly 300,000 more hand sprayers would be needed for timely application of agro-chemicals.

Weed control by mechanical means is practiced by less than 1% of total area (FMRC). The basic requirement for application of any type of mechanical weeder is to have a crop established in rows. In Sri Lanka two types of weeders are used. They are Japanese single and two row designs and IRRI conical type single and two row versions. The comparative study by FMRC indicates that the IRRI conical weeder has superior characteristics in the cases of capacity, manuarability, and also simplicity in manufacture. The capacity of this weeder (0.25 ha/day) also would have to be increased to gain popularity. Further studies should be carried out to introduce a self-propelled weeder, which could be handled by one operator, having a capacity of nearly a ha/day (Table 3).

Table 3. Cost comparison of weeding techniques.

Method	*Cost/ha Rs.*	*Advantages*	*Disadvantages*
Chemical weeding	4000	Easy and quick, Method of establishment of crop is immaterial.	Hazardous to the environment, Development of resistance by weeds for weedicides, Control depends on weather.
Mechanical weeding	1000	Environmentally friendly, Efficient use of fertilizer. Weather condition is immaterial.	Crops should be established in rows.

Harvesting and threshing

The survey conducted by FMRC, Silsoe college, and University of Peradeniya in 1991 indicated that Harvesting and threshing is the most labour intensive operation requiring immediate attention providing a suitable mechanical aid. Mechanization of this operation has been attempted to do in three steps; first the threshing and then reaping and finally the combine harvesting. The threshing by conventional methods in particular was reported to be unsatisfactory when quality is considered. A study conducted by the RPRDC revealed that the mechanical threshing could give a quality output with less cracked grains increasing the percentage of head grains in milling. In addition, because of the absence of impurities mixed with the grain there is an increased demand by the mill owners on such paddy. The other two main methods, namely the tractor threading and buffalo trampling, were reported to be unsuitable for excessive cracked grains and impurities found in the output (Table 4). If properly handled the mechanical threshing also could be made use of for reducing field losses that could incur during reaping and threshing. In the conventional methods, a substantial quantity of paddy go waste as shattering losses when transporting the reaped crop to the threshing ground. The straw thus transported is set on fire later after collecting the paddy, loosing a valuable organic matter and nutrient. The portable mechanical threshers can leave the straw spread in partially chopped form in the field itself facilitating easy digestion. This method also averts the requirement of transporting the cut crop to the threshing ground, which incur extra labour cost.

Table 4. Performance comparison of threshers with the buffalo and tractor.

	Buffalo	*Tractor*	*Threshers*
Impurities %	4.4	7.8	0.3
Cracked grains %	7.8	11.7	6.3
Loss in head rice %	6.2	7.0	2.0
Moisture %	15.2	14.7	14.1

(Source: RPRDC 1983)

Reaping

This operation is done almost 100% by using sickles. Requirement of a mechanical reaper has been indicated in all surveys conducted by FMRC and efforts were made to introduce IRRI designed self-propelled machine. This attempt was not successful due to the high cost of the machine. In order to overcome this problem a reaping attachment to a popular two-wheel tractor was designed and introduced. This attachment had a good demand, but the limited applicability on lodged crops restricted the potential market.

Combine Harvesters

The labour scarcity has now become so aggravated that the harvesting and threshing operations could not be done in time resulting in heavy yield losses. In order to overcome this situation, farmers in the large-scale paddy growing areas sought after combine harvesters to take over the task. Unfortunately the exorbitant prices of new combine harvesters directed the farmers to look for second hand machinery imported from Japan and Korea. These machines had two main disadvantages. Firstly, the frequent repairs needed and secondly, the inability of the machines to work on the lodged crops. In a test conducted by FMRC it was revealed that the capacity of such a machine was nearly one hectare per day and the shattering losses was amounting to about 5- 10 % (FMRC 2000). The losses could be attributed to the way in which the plants have been established, ground moisture condition, plant growth, operator's skill and machine condition. The shattering losses mainly occurred due to the inability of the machine to properly gather the broadcast crop onto the cuter bar.

In contrast to the above head feed type combine harvester from Japan, a whole crop type machine imported from China gave some encouraging results. Because the disadvantages associated with the Japanese one could have been mitigated by making the machine smaller and by having an adjustment to cut the crop as close as possible to the panicle. The price is also at the affordable limit to the farmer.

STATISTICS OF MANUFACTURERS OF AGRICULTURAL MACHINERY

Most of the agricultural machinery & equipment needed by the country are manufactured locally, except tractors and combined harvesters. Majority of manufacturers belong to private sector. Many large companies manufacturing agricultural machinery are located in Colombo or suburbs. They are usually subsidiaries of groups of companies. Medium and small-scale industries are distributed in the major townships in the island and cater mostly to the local and provincial needs. The present strength of manufacturers of each category is given in table 5.

Table 5. Strength of manufacturers in each category of scale.

Category	*Number*	*Types of machinery produced*
Large-scale	10	Power tillers, Paddy reapers, Paddy threshers, knapsack & power sprayers, Paddy milling machinery, Electric & engine driven water pumps, Nine tine tillers, Cage wheels, Some tractor parts and trailers.
Medium-scale	25	Seeders & weeders, Cage wheels, Trailers, Winnowing fans, Animal drawn equipment, Rotavator blades and paddy processing machinery.
Small-scale	232	Mammoties & hoes, Sickles, Seeders & weeders, Rotavator blades, Levelers and Harrows.

CONCLUSION & SUGGESTIONS

The continuously increased gap between the required and available farm power created due to migration of labour from the farm, increased demand for higher quality agricultural products by both national and international markets, gradually decreasing individual farmer income could be sufficiently attended by having a carefully planned appropriate type of agricultural mechanization process. Through proper mechanization environmental hazards also could be substantially mitigated. As it has been done in the past piecemeal type of solutions may not be able to bring about the expected results. The land and crop conditions must be made conducive for efficient application of machinery and tools. Steps would have to be taken to avert the basic obstructions, as identified below, for introduction of recommended mechanization technologies.

- Low demand by the end users for agricultural machinery; There are several factors such as lack of awareness, lack of resources for purchasing machinery, lack of appropriate type of agricultural machinery, farmers attitudes and small plot sizes contributing for the low demand.
- Farmers loss of confidence on farm machinery; Poor accessibility to machinery, inadequate production of low cost machinery, small farm sizes, lack of incentives for farmers to improve productivity & quality and lack of after sale services are few of the reasons for this.
- Poor planning in the field of farm mechanization; this has caused mainly due to the in-availability of a policy on mechanization and the failure to identify the appropriate machinery.

- No effective grass root level extension; This has basically incurred due to absence of grass root level extension, lack of skills by the officers and lack of integration of research and extension in farm mechanization.

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CHAPTER 4

TECHNOLOGY TRANSFER AND INPUT SUPPLY